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Final Report

LANDSLIDE REMEDIATION USING UNCONVENTIONAL METHODS

Richard J. Deschamps
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September 1999

Indiana
Department
of Transportation

Purdue
University

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LANDSLIDE REMEDIATION USING UNCONVENTIONAL METHODS

By

Richard J. Deschamps*
Senior Geotechnical Engineer
FMSM Engineers
Lexington, Kentucky
Principal Investigator

Cary B. Lange
Research Assistant

School of Civil Engineering
Purdue University

** formerly a Purdue University Civil Engineering faculty member*

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16. Abstract

Landslides are very common within the residual soils and sedimentary rock of Southern Indiana. A substantial amount of the Indiana State budget is spent on road repair and maintenance from damage caused by landslide. The landslide remedial technique frequently applied by the Indiana Department of Transportation (INDOT) is the excavation and backfill method, which in most instances is successful. However, in many cases more liberal landslide treatments may be applied that would arrest movement, provide a sufficient safety factor, and at a lower cost. The objective of this study is to propose economically feasible landslide remedial methods that may be used as an alternative to the excavation and backfill method.

"Unconventional" landslide remedial methods describe stabilization methods that are not commonly practiced in Indiana, and for which design criteria are not available. Unconventional stabilization methods will likely have the greatest benefit applied to relatively small landslides requiring constant maintenance because these landslides are in a delicate equilibrium. Relatively modest improvements in stability may be sufficient to stop persistent movements. Proposed landslide remedial methods are conventional horizontal drains, driven horizontal wick drains, driven recycled plastic pins, railroad rail piles, lime piles, biotechnical remediation, and gravity mass retaining systems.

A landslide inventory containing various attribute information of geologic environment and landslide geometry was compiled. The inventory includes 284 landslides with attribute information of each individual landslide. Landslide locations were entered into a geographic information system (GIS) database along with geographic and geologic information. The constructed GIS database allowed easy correlation of landslide occurrence with geologic features. It is concluded that landslide occurrence is a function of topography and bedrock geology.

Suitability of landslide stabilization methods depends upon the characteristics of the sliding mass, which include the geologic environment and geometry of the landslide. A landslide classification scheme was developed which recommends suitable remedial solutions based upon the landslide classification. Eleven landslide types are recognized by the classification scheme, which is based upon four landslide attributes.

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IMPLEMENTATION REPORT

Landslides are a common occurrence within constructed highway embankments and cut slopes throughout Southern Indiana. Stabilizing existing landslides is very expensive; repair of major slides has cost as much as $2800 per lineal foot of repair. A recent repair of State Road 56 in Dearborn County exceeded 10 million dollars. The persistent maintenance needs of many smaller slides are also very costly, consuming a substantial part of the state annual budget for roadway maintenance. The Indiana Department of Transportation (INDOT) typically applies the excavation and backfill method, which in most cases proves successful. However, in many cases more liberal landslide treatments may be applied that would arrest movement, provide a sufficient safety factor -and at a lower cost. The objective of this study is to propose economically feasible landslide remedial methods that may be used as an alternative to the excavation and backfill method.

"Unconventional" landslide remedial methods describe stabilization methods that are not commonly practiced in Indiana, and for which design criteria are not available. Unconventional stabilization methods will likely have the greatest benefit applied to relatively small landslides requiring constant maintenance because these landslides are in a delicate equilibrium. Relatively modest improvements in stability may be sufficient to stop persistent movements. Proposed landslide remedial methods are conventional horizontal drains, driven horizontal wick drains, driven recycled plastic pins, railroad rail piles, lime cement columns, biotechnical remediation, and gravity mass retaining systems.

The accomplishments of this study are the following:

- Compilation of a landslide inventory of 284 landslides within the State of Indiana, including various attribute information of each individual landslide.
- Construction of a geographic information system (GIS) database illustrating spatial relationship of landslides with geographic and geologic information.
- Correlation of landslide occurrence with geologic features using the GIS database.
- Proposal of cost-effective landslide remedial methods.

- Development of a landslide classification scheme, which recommends suitable remedial solutions based upon the landslide classification.

Suitability of landslide stabilization methods depends upon the characteristics of the sliding mass, which include the geologic environment and geometry of the landslide. The landslide inventory and the GIS database were constructed to summarize existing landslide data and also to realize trends and to correlate landslides with geologic environment. The inventory and GIS database includes 284 landslides with attribute information of each individual landslide. The landslide inventory was constructed in Excel spreadsheet format and may be revised as landslides occur and reoccur, and also be updated as landslide attribute information is better quantified. The compiled landslide inventory and constructed GIS database are significant accomplishments peripheral to the main focus of the study that should prove a valuable tool that INDOT may build upon.

Landslide locations were entered into ArcView, GIS software, along with other geographic and geologic information. The constructed GIS database allowed easy correlation of landslide occurrence with geologic features. It is concluded that landslide occurrence is a function of topography and bedrock geology. Also, because landslide distribution within Indiana is now well defined, the affect of standard design procedure and construction methods within areas prone to landslides may be more closely observed and refined within these areas.

GIS applied to engineering practice offers a convenient means for data management, storage and manipulation. This potential is currently partially realized. The ease and convenience of data retrieval, correlation, manipulation, and storage for individual landslides offers exciting benefits to landslide analysis and control. Correlation of landslide attributes may enable the user to easily identify or hypothesize the cause and mechanism of failure and may aid in identifying applicable remedial methods.

The main focus of the study was upon investigating and proposing cost-effective landslide remedial methods. Considerable cost savings is realized from the proposed methods. Horizontally installed wick is a relatively new concept and has recently been the focus of research at the University of Missouri-Rolla. Using driven horizontal wick drains are so inexpensive that they may be used in order to provide additional stability to slopes that have not yet failed. Installation cost is estimated between 3 to 5 dollars per

lineal foot and is expected to decrease after experience allows for optimization of the installation technique. Railroad rails piles installed in predrilled vertical holes are commonly used by the Kentucky Transportation Cabinet to stabilize road embankments sliding upon bedrock. Estimated costs using this method are estimated at 8 to 10 dollars per foot of installed rail. Installed rail piles offer considerable cost savings compared to the excavation and backfill method.

Finally, a landslide classification scheme was developed which recommends suitable remedial solutions based upon the landslide classification. Eleven landslide types are recognized by the classification scheme, which is based upon four landslide attributes.

1. The landslide failure plane, whether it occurs entirely within soil or in any part along the soil-bedrock interface.
2. The slope geometry, cut slope or embankment fill.
3. The depth of the failure surface.
4. The distance the landslide scarp is from the roadway shoulder (applies only to embankment fills).

The inventory and GIS database were created so that landslide data could be more efficiently managed, and to enabled correlation of landslide occurrence with geologic features. Because landslide distribution within Indiana is now well defined, the affect of standard design procedure and construction methods within areas prone to landslides may be more closely observed and refined within these areas. Refining standard construction technique and procedure could dramatically reduce the number of landslides that affect constructed roadways, reducing the impact landslide maintenance has upon the state budget. Furthermore, cost savings may be realized from the proposed remedial methods: the proposed landslide remedial methods are typically less expensive than the standard excavation and backfill method.

1.0 INTRODUCTION

1.1 Problem Statement

Landslides are very common within the residual soils and sedimentary rock of Southern Indiana. Many of these landslides cause damage to roadways within the state and have a very detrimental and costly impact on the state highway system. The level of damage ranges from requiring relatively minor periodic maintenance to putting the road completely out of service. Stabilizing existing landslides is very expensive; repair of major slides has cost as much as $2800 per lineal foot of repair. A recent repair of State Road 56 in Dearborn County exceeded 10 million dollars. The persistent maintenance needs of many smaller slides are also very costly, consuming a substantial part of the state annual budget for roadway maintenance.

"Unconventional" landslide remedial methods, as termed within the report title, describe stabilization methods that are not commonly practiced in Indiana, and for which design criteria are not available. Unconventional stabilization methods will likely have the greatest benefit applied to relatively small landslides requiring constant maintenance because these landslides are in a delicate equilibrium. Relatively modest improvements in stability may be sufficient to stop persistent movements.

The landslide remedial technique frequently applied by the Indiana Department of Transportation (INDOT) is the excavation and backfill method, which in most instances is successful. This method requires excavating the failed mass, sometimes constructing a key into competent material (to provide further stability), and backfilling the excavated portion with riprap (see Figure 1 and Figure 2). However, in many cases more liberal landslide treatments may be applied that would arrest movement, provide a sufficient safety factor, and at a lower cost. The objectives of this study are the proposal economically feasible landslide remedial methods and, the development of a landslide classification scheme, which recommends applicable remedial solutions based upon the landslide classification.

Figure 1. Landslide remediated using the excavation and backfill method on SR 64 in Crawford County.

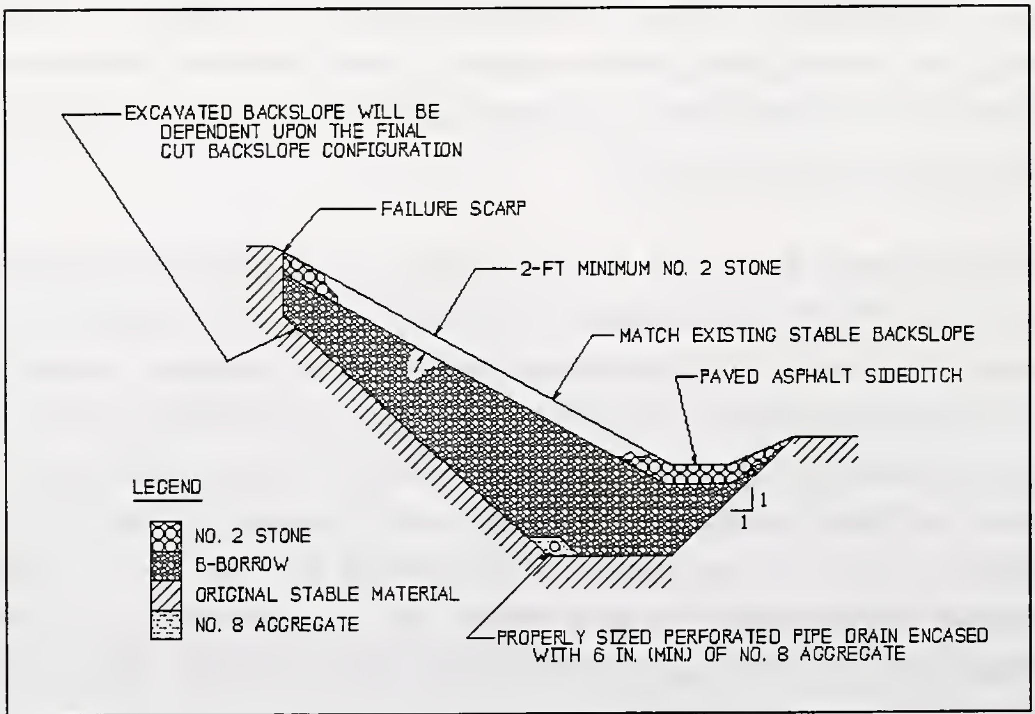

Figure 2. Cross-section view of typical excavation and backfill treatment. 'B'-Borrow is optional and may be replaced with stone.

1.2 Project Approach

Proposed landslide remedial methods are conventional horizontal drains, driven horizontal wick drains, driven recycled plastic pins, railroad rail piles, lime cement columns, biotechnical remediation, and gravity mass retaining systems. In order to recommend more cost-effective landslide remedial methods, and to develop a landslide classification scheme, a landslide inventory was performed and the inventory was entered into a constructed geographic information system (GIS) database. The GIS database also allowed correlation of landslide occurrence with geologic features. Summarizing, the accomplishments of this study are the following:

- Compilation of a landslide inventory of 284 landslides within the State of Indiana, including various attribute information of each individual landslide.
- Construction of a GIS database illustrating spatial relationship of landslides with geographic and geologic information.
- Correlation of landslide occurrence with geologic features using the GIS database.
- Proposal of cost-effective landslide remedial methods.
- Development of a landslide classification scheme, which recommends suitable remedial solutions based upon the landslide classification.

Suitability of landslide stabilization methods depends upon the characteristics of the sliding mass, which include the geologic environment and geometry of the landslide. The landslide inventory and the GIS database were constructed to summarize existing landslide data and also to realize trends and to correlate landslides with geologic environment. The inventory and GIS database includes 284 landslides with attribute information of each individual landslide. The landslide inventory was constructed in Excel spreadsheet format and may be revised as landslides occur and reoccur, and also be updated as landslide attribute information is better quantified. The compiled landslide inventory and constructed GIS database are significant accomplishments peripheral to the main focus of the study that should prove a valuable tool that INDOT may build upon.

Landslide locations were entered into ArcView, GIS software, along with other geographic and geologic information. The constructed GIS database allowed easy correlation of landslide occurrence with geologic features. It is concluded that landslide

occurrence is a function of topography and bedrock geology. Also, because landslide distribution within Indiana is now well defined, the affect of standard design procedure and construction methods within areas prone to landslides may be more closely observed and refined within these areas.

The main focus of the study was upon investigating and proposing cost-effective landslide remedial methods. Considerable cost savings is realized from the proposed methods. A landslide classification scheme was development and recommends suitable remedial solutions based upon the landslide classification. Eleven landslide types are recognized by the classification scheme, which is based upon four landslide attributes.

5. The landslide failure plane, whether it occurs entirely within soil or in any part along the soil-bedrock interface.
6. The slope type, cut slope or embankment fill.
7. The depth of the failure surface.
8. The distance the landslide scarp is from the roadway shoulder (applies only to embankment fills).

The inventory and GIS database were created so that landslide data could be more efficiently managed, and to enabled correlation of landslide occurrence with geologic features. Because landslide distribution within Indiana is now well defined, the affect of standard design procedure and construction methods within areas prone to landslides may be more closely observed and refined within these areas. Refining standard construction technique and procedure could dramatically reduce the number of landslides that affect constructed roadways, reducing the impact landslide maintenance has upon the state budget. Furthermore, cost savings may be realized from the proposed remedial methods: the proposed landslide remedial methods are typically less expensive than the standard excavation and backfill method.

Details of the landslide inventory, GIS database, the correlation of landslide occurrence with geologic features, proposed remedial methods, and the landslide classification scheme are discussed.

2.0 INDIANA LANDSLIDE INVENTORY

2.1 Inventory Compilation

Landslides included in the inventory are only those occurring adjacent to Indiana roadways. Landslides not included in the inventory are those not occurring next to Indiana roadways, and also those occurring adjacent roadways along the Ohio River. Landslides occurring adjacent to roadways along the Ohio River tend to be very large landslides, affecting extensive area, and are not considered within the scope of the report.

The landslide inventory includes 284 landslides with attribute information pertaining to the geologic environment and geometry of each individual landslide. Specific landslide attribute information and the corresponding source of the information are included in Table 1. Landslide attribute information is included in the inventory to aid landslide classification and also to aid in selection of proposed remedial methods. Adequate information is not available for many attributes of landslides and therefore remains blank within the inventory. The landslide inventory was constructed in Excel spreadsheet format and may be revised as landslides occur and reoccur, and also be updated as landslide attribute information is better quantified. A copy of this file is provided on disc in Appendix A. A hard copy of the landslide inventory is included as Appendix B.

Table 1. Landslide Inventory Attributes.

Landslide Attribute	Data Source
Landslide location	*INDOT files or field survey*
Probable cause	*INDOT files or field survey*
Remedial method implemented or considered	*INDOT files or field survey*
Correction status	*INDOT files or field survey*
Description of vegetation	*field survey*
Failure location relative to entire slope	*INDOT files or field survey*
Slope type (embankment or cut slope)	*INDOT files or field survey*
Slope severity (in degrees from horizontal)	*INDOT files or field survey*
Landslide classification (Varnes, 1978)	*INDOT files or field survey*
Underlying bedrock formation	*GISH database*
Landslide length & width	*INDOT files or field survey*
Approximate depth to failure surface	*Borelogs or INDOT field investigations*
Average depth of overburden	*Borelogs or INDOT field investigations*
Estimated area and volume	**estimated from length, width & depth*
Availability of bore logs	*INDOT files*
Availability of field sketches	*INDOT files*
Availability of slope inclinometer data	*INDOT files*
Earliest reported date of failure	*INDOT files*
Date of road construction and rehabilitation	*INDOT Bridge Inventory Report*

Project files on record at the INDOT Division of Materials and Tests Headquarters in Indianapolis, Indiana, and field surveys conducted during the summer of 1998, provided all information included in the inventory. Information found within INDOT project files typically include the following: landslide field investigation forms, formal reports of landslide correction, borelogs, slope inclinometer data, correspondence information and other miscellaneous information. Landslide field investigation forms may include field sketches and geometric information of the landslide, estimated depth of overburden within the landslide site, and postulated cause and failure mechanism of the landslide. Formal reports of landslide correction often contain borelogs and other subsurface information as well as scaled cross-sections of the landslide.

Field surveying conducted at landslide sites during the summer of 1998 provided profile data for determining slope angle. Qualitative observations such as existing vegetation within the landslide site and the correction status of the landslide were also made during field surveying.

2.2 Landslide Attributes

The correction status, slope type, and landslide classification are summarized in Table 2. Of the landslides, 131 are corrected, 134 uncorrected, and the correction status is unknown for 19 landslides. Most landslides corrected were so using the excavation and backfill method. A little more than half of the landslides, 146, occur within embankments, while 135 occur within cut slopes and 3 encompass both an embankment and cut slope. Cut slope failures are common along I-64: 57 of 134 cut slope failures occur along this highway. Landslides were classified as either earth slumps or earth slump on bedrock landslides, which is in accordance to the widely adopted landslide classification proposed by David Varnes in 1978 (Cruden and Varnes, 1996). Fifty-two landslides are classified as earth slumps, and 132 are classified as earth slump on bedrock landslides. Landslide classification is unknown for 100 landslides.

Table 2. Summary of Landslide Attribute Information.

Landslide Attribute	Number of Landslides
Correction Status	
corrected	131
uncorrected	134
unknown	19
Slope Type	
embankment	146
cut slope	135
both	3
Landslide Classification	
earth slump	52
earth slump on bedrock	132
unknown	100

Earth slump landslides are those in which failure occurs entirely within unconsolidated sediments. Earth slump on bedrock landslides are those in which failure occurs, in some part, along the soil-bedrock interface. Inclinometer data is rarely available to aid landslide classification. The landslide classification was often obtained from INDOT landslide field investigation forms where the landslide failure surface is often postulated to occur along the soil-rock interface. Landslides are assumed to be an earth slump if

the depth of overburden within the site is known to be significantly greater than the size of the landslide.

A histogram of slope severity calculated from profile data of landslides is illustrated in Figure 3. Three distinct peaks occur at approximately 18, 22, and 26 degrees, which correspond to 3:1, 2.5:1 and 2:1 horizontal to vertical slopes: so it is observed that many landslides occur within engineered embankments and cut slopes.

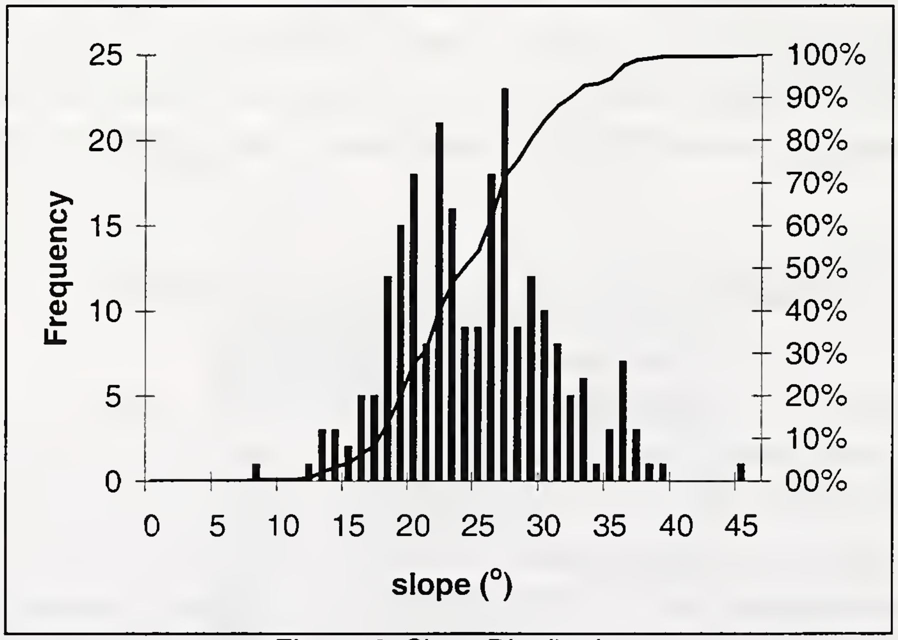

Figure 3. Slope Distribution.

The length (L), width (W), and depth (D) quantify the landslide geometry. These dimensions are illustrated in Figure 4. The depth to failure surface (D) is defined as the maximum depth from the ground surface to the surface of rupture (Varnes, 1978). D is approximated from either borelogs or slope inclinometer data if such information is available. For earth slump on bedrock landslides, D is assumed to be the average depth of overburden within the site. If borelogs are not available, the depth of overburden is that estimated in INDOT landslide field investigation forms.

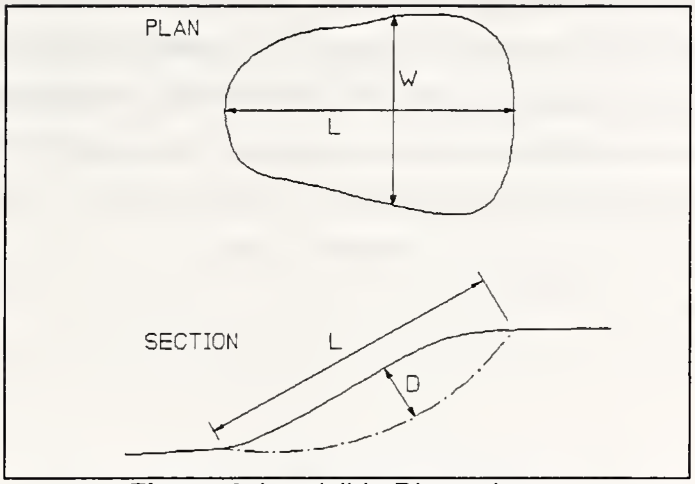

Figure 4. Landslide Dimensions.

The landslide volume is estimated for 163 landslides and could not be estimated for many landslides because of limited available information. Estimated landslide volume ranges from 100 to 84,000 yds^3, averaging 6700 yds^3. Landslide volume is estimated using Equation 1, which is half the volume of the ellipsoid defined by semiaxes L, W, and D (Cruden and Varnes, 1996).

$$\mathrm{VOL_{ls}} \equiv \frac{\pi}{6} L \bullet W \bullet D \tag{1}$$

The area of the landslide is considered an alternative method of estimating and relating landslide size in the absence of data necessary to estimate the landslide volume. Landslide area is estimated as the area of an ellipse, assuming the dimensions L and W are axes of an ellipse. The calculated area for 274 landslides range from approximately 30 to 25,000 yds^2 and the average is 1560 yds^2. Most landslide areas are less than 2,200 yds^2.

A photographic log was compiled coincidentally while conducting field surveying. For most landslides, reference is given to where the picture of the landslide can be found within the photo log. The photo log proved to be invaluable when assimilating data regarding the respective landslides.

Vegetative cover was observed during field surveys and is described qualitatively within the inventory. Notice was taken to the presence of cattails, which are inherent in very wet areas where the groundwater table is high or perched water exists, indicating that the cause may likely be attributed to groundwater, and therefore, subsequent remedial action should incorporate subsurface drainage. Figure 5 is a photograph showing cattails in the ditch line at the toe of a corrected landslide.

Figure 5. Cattails in ditch near toe of remediated landslide adjacent to I-64 in Vanderburgh County.

Table 3. Summary of Probable Landslide Causes.

Suspect Cause	Number of Landslides
Slope Too Steep	64
Creek at Toe	50
Groundwater at Soil-Rock Interface	40
Miscellaneous Drainage	40
Sloping Bedrock	37
Engineering of Fill	31
Failed Internal Drainage Structure	25
Drainage Structures Adjacent to or within Slide	14
Failed CPID	12
Removal of Toe by Ditch Maintenance	7

The suspected cause or causes of most landslides are also included in the inventory. Individual landslides often have more than one suspected cause. The suspected causes were most often obtained from INDOT field investigation forms. Table 3 provides a list of the number of landslides attributed to specific causes. One or more suspected causes are included in the inventory for 227 of the 284 landslides. The most common cause is that the slope was designed and constructed too steep for the soil involved. Perhaps routine slope stability calculations did not adequately model the existing conditions and as a result the slope was constructed too steep for the existing conditions.

Fifty landslides occur adjacent to a stream. Erosion of the toe material of the landslide may have contributed to instability but it is not certain if this is the case for all landslides adjacent to streams. Stream bank erosion may occur very gradually so that settlements observed in the roadway are relatively insignificant over a long period of time and require patching or repair infrequently. Protecting the stream bank from erosion may prevent movements such as this, and will likely not be effective for landslides that occur due to relatively rapid loss of soil at the toe.

The suspected cause for 40 landslides is groundwater at the soil bedrock interface. Water at the soil-bedrock interface not only reduces effective stress, but also facilitates weathering and increases the total weight of the soil. Also transient flow conditions produce seepage forces in the direction of flow.

The miscellaneous drainage category in Table 3 includes forty landslides. These landslides are suspected to be due to poor drainage. Poor drainage may be evident because the slope was saturation due to drainage outlets surfacing upon the slope, groundwater seeps are visible upon the slope, or erosion of the landslide toe is evident.

Thirty-seven landslides are suspected to be due to steeply sloping bedrock underlying the soil mantle. Such conditions may not have been taken into consideration during the design of cut/fill sections of roadway. Adequate benching and drainage of the natural ground underlying the placed embankment fill may not have been provided, which was common of past engineering design and construction.

For 31 landslides, improperly engineered fill is listed as the probable cause. This could mean that the fill was placed when conventional practice dictated that compaction occur dry of the optimum moisture content. Fill placed as such is susceptible to drastic strength reduction upon saturation, which may eventually occur decades after construction.

Failed internal drainage structures are the suspected cause for 25 landslides. This often occurs where corrugated metal pipe (CMP) drains underneath highway embankments become clogged with debris. The slope then becomes saturated after water backs up due to clogging. Because this is always a potential problem wherever drainage structures occur, the existence of internal drainage structures within and adjacent to all landslides is noted in the inventory.

Twelve landslides are thought to have occurred due in some part to concrete paved interceptor (CPID) ditches that failed. Severe erosion often occurs parallel to the ditches between the edge of the CPID and the soil. Erosion opens channels for surface water to infiltrate into the subsurface, which may eventually cause failure. Figure 6 is a photograph showing erosion along a CPID that may have contributed to slope failure.

Finally, for seven landslides it is thought that routine ditch maintenance may have caused instability, which removed needed toe support from the slope. Figure 7 illustrates recent ditching near the toe of an active landslide.

Although not mentioned within INDOT project files, it is suspected that many landslides occurring within embankments may be shallow seated due to inadequate compaction. Adequate compaction is difficult to achieve along the edge of the embankment throughout the construction process, resulting in relatively loose material near the fill surface throughout the embankment height. These shallow sloughs occur within the loose material after the slope becomes saturated and are shallow seated translational failures. For such failures, traditional slope stability calculations are not applicable, and erosion control is the primary concern. Typically shallow surface sloughing such as this is economically remediated using the excavation and backfill method.

Figure 6. CPID at head scarp of landslide on SR 37 2.1 miles north of SR 54 in Lawrence County.

Figure 7. Fresh ditching at the toe of an active landslide adjacent to I-64 in Vanderburgh County.

3.0 GEOGRAPHIC INFORMATION SYSTEM (GIS) DATABASE

3.1 GIS Database Construction

Geographic information systems (GIS) provides a convenient means for the management, storage and manipulation of spatial information. ArcView and Arc/Info, GIS software, was utilized to construct, manipulate and manage geographically referenced information, and allowed easy and relatively accurate correlation of landslide occurrence with geological features.

Within ArcView, constructed layers or themes of geographically referenced information may be superimposed to enable correlations and realize trends. Landslide locations were superimposed upon various geologic themes in order to correlate landslide occurrence with geologic features. The following is a list of themes included in the constructed GIS database. Most themes were obtained from the Indiana Department of Natural Resources. The Arcview project file including all themes used in the constructed GIS database are provided in Appendix A on computer disc.

- Individual landslide locations
- State, interstate and US highways in Indiana
- County and state political boundaries
- Hillshaded Digital Elevation Model (DEM) topographic representation
- Physiographic provinces
- Bedrock geology
- Surficial soil geology
- Depth of overburden
- Glacial advance limits

3.2 GIS Application and Potential

GIS applied to engineering practice offers new and exciting potential for the management, storage and manipulation of data. This potential is currently partially realized. The constructed GIS database should prove to be a valuable tool that INDOT

may build upon and utilize more extensively. GIS may also be used to map other geologic hazards common to Indiana.

Borelogs, piezometer and inclinometer data, as well as large scale site specific topographic maps and sketches, photographs, rainfall data, and other information of individual landslides may all be stored in a GIS database. Ideally such information can be stored and displayed as follows. Within the computer environment, a more site-specific large-scale topographic map is displayed by clicking on individual landslide locations with a mouse. The cued topographic map may also illustrate boring, inclinometer, and piezometer locations, landslide boundaries and other information. Clicking on a borelog location then displays the individual borelog or clicking on the inclinometer location displays the inclinometer data and may even coincidentally display rainfall data for correlation of landslide movement with precipitation.

The ease and convenience of data retrieval, correlation, manipulation, and storage for individual landslides offers exciting benefits to landslide analysis and control. Correlation of landslide attributes may enable the user to easily identify or hypothesize the cause and mechanism of failure and may aid in identifying applicable remedial methods. Realizing trends of landslide attributes may also aid in preventing future failures. Also, because landslide distribution within Indiana is now well defined, the affect of standard design procedure and construction methods within areas of landslides may be more closely observed and refined within these areas.

4.0 GEOLOGY AND LANDSLIDE CORRELATION

4.1 Overview of Indiana Geology

The glacial advance limits of the Illinoian and Wisconsin Glacial events dissect the northern and southern half of Indiana in two distinct geomorphologic regions. The northern half of Indiana consists of vast glacial plains formed from the Illinoian and Wisconsin glacial events. Glacial till deposits can be hundreds of feet thick within this region and bedrock seldom outcrops at the surface. Residual soil is the dominant unconsolidated deposit beyond the glacial advance limits within the southern half of Indiana, which is where landslides are common. Here the depth to bedrock is much shallower, typically less than 50 feet, and bedrock outcrops are common.

The bedrock structure is defined by three major dominant structures within or adjacent to Indiana. The Illinois basin is to the west of Indiana and the Michigan Basin is to the north of Indiana. The basins are separated by the Cincinnati arch, which extends from the southeast corner of the state to the northwest corner as illustrated in Figure 8.

Underlying bedrock strata of Southern Indiana consists of Ordovician age bedrock, the oldest bedrock within the state, to Pennsylvanian age bedrock, the youngest bedrock in the state. Pennsylvanian age bedrock underlies Southwest Indiana, Mississippian age bedrock in South Central Indiana followed by Devonian, Silurian and Ordovician age bedrock in Southeast Indiana. The aerial extent of bedrock within the state is illustrated in Figure 9.

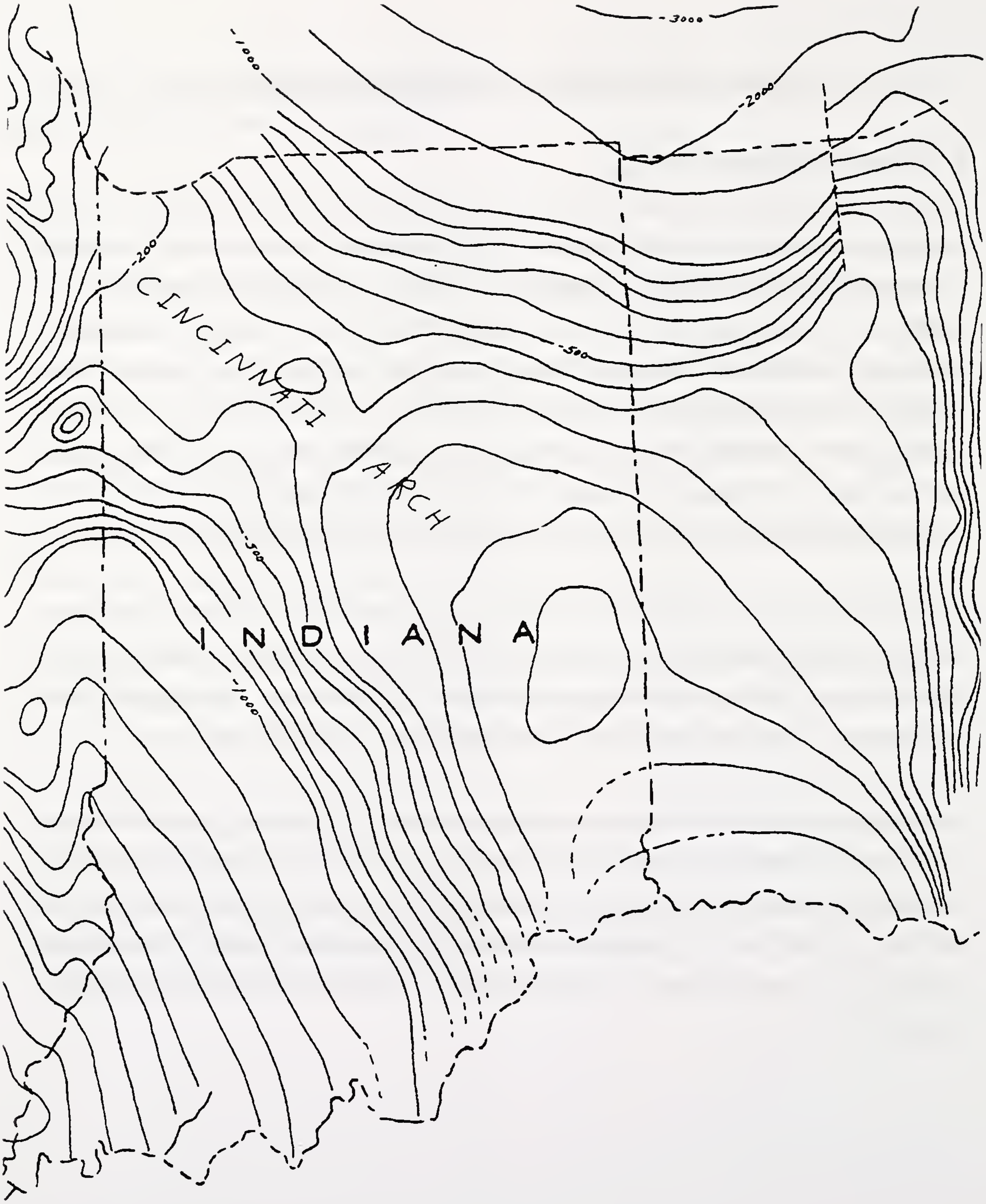

Figure 8. Regional structural relief of Trenton Limestone illustrating Cincinnati Arch (Frey and Lane, 1966).

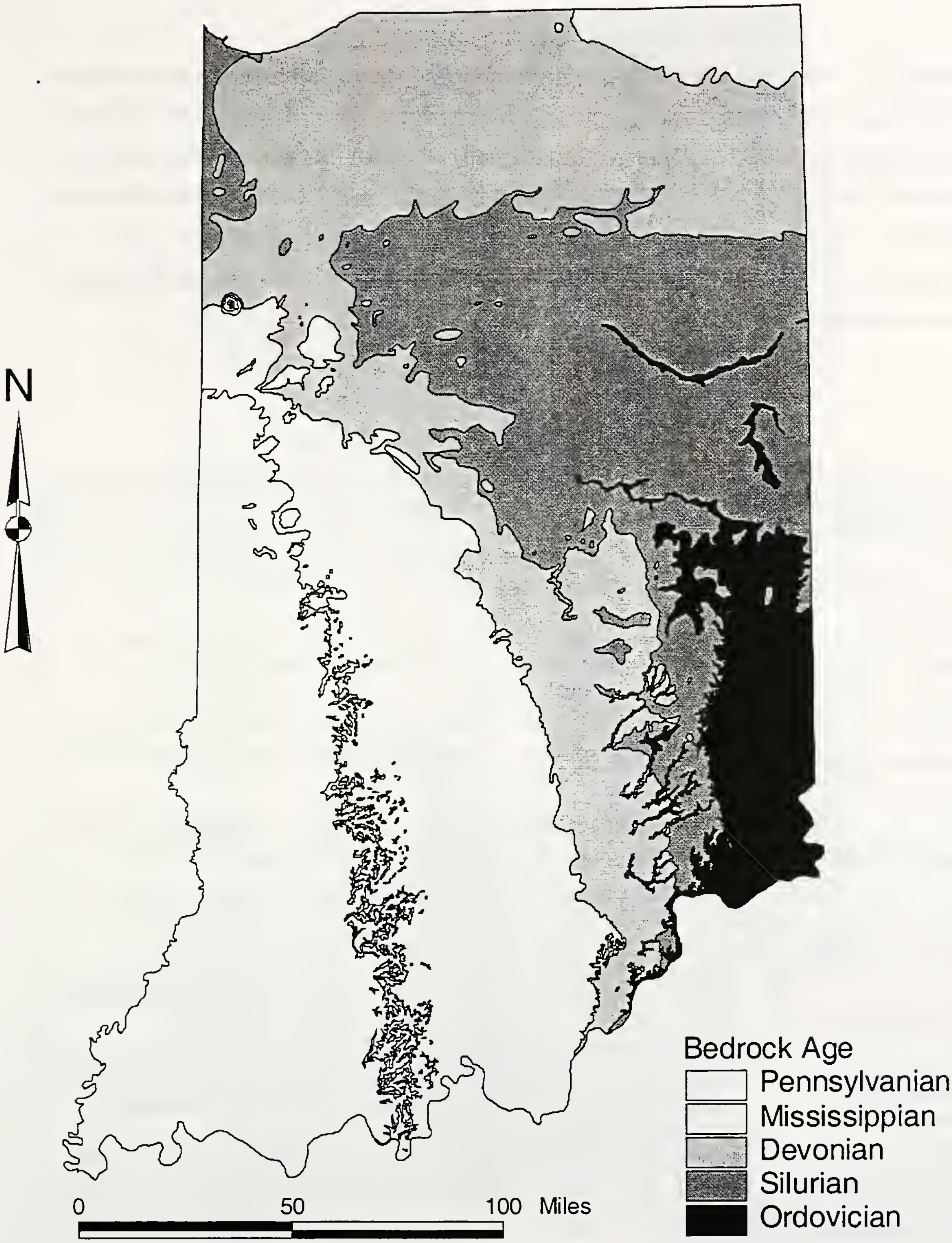

Figure 9. Bedrock Age.

Indiana is divided into eight physiographic regions. Physiographic regions are areas of similar geologic structure and geomorphic history and contain similar landforms; these are the Wabash Lowland, Crawford Upland, Mitchell Plain, Norman Upland, Scottsburg Lowland, Muscatatuck Regional Slope, Dearborn Upland and Tipton Plain Physiographic Regions. Landform characteristic descriptions of each physiographic region are provided in Table 4 and Figure 10 illustrates the boundary of each physiographic region within the state.

Table 4. Physiographic Regions of Indiana
(As Interpreted by H.H. Gray, Indiana Geologic Survey, April 1975.).

Physiographic Region	Description
Tipton Till Plain	Broad gently rolling plain. 90% is suited to general agriculture, but about 2/3 of this is subject to wetness. Remainder is steep slopes.
Wabash Lowland	Broad valley flats and low rolling hills. 80% is suited to general agriculture, but about half of this is subjected to wetness. Remainder is steep slopes.
Crawford Upland	Hilly land with cliffs and outcrops of sandstone and limestone. 65% is steep slopes. Remainder is suited to agriculture, mostly to pasture.
Mitchell Plain	Rolling limestone plateau crossed by deep rocky valleys. 50% is suited to agriculture, mostly to pasture. Remainder is steep slopes.
Norman Upland	Hilly land with rocky slopes and outcrops of siltstone. 65% is steep slopes. Remainder is suited to agriculture, mostly to pasture.
Scottsburg Lowland	Broad valley flats and low rolling hills. 80% is suited to general agriculture, but about half of this is subject to wetness. Remainder is steep slopes.
Mascatatuck Regional Slope	Rolling limestone plateau crossed by deep rocky valleys. 70% is suited to general agriculture, but about half of this is subject to wetness. Remainder is steep slopes.
Dearborn Upland	Hilly land with rocky slopes and outcrops of limestone and shale. 60% is steep slopes. Remainder is suited to agriculture, mostly to pasture.

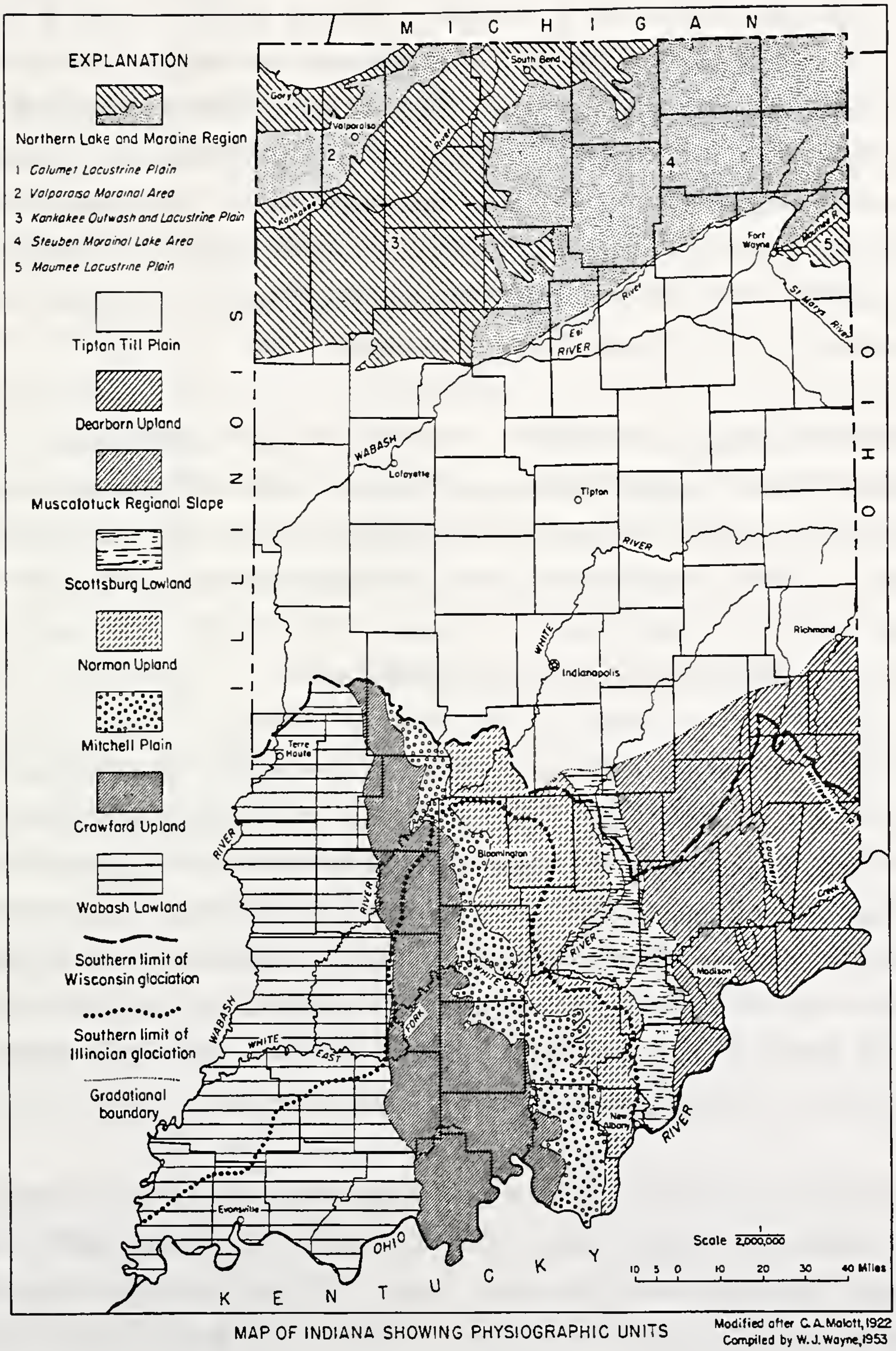

Figure 10. Physiographic Regions of Indiana (Gray, 1975).

4.2 Correlation of Landslide Occurrence and Geology

Figure 11 illustrates an overview of landslide occurrence within the state of Indiana relative to the Indiana highway network. It is observed that landslides occur in two primary clusters- South Central Indiana and Southeastern Indiana. There is a small cluster of 36 landslides in Southwest Indiana, 23 of which are failures within cut slopes. Of the cut slope failures, all but 2 are classified as earth slumps. Relatively short and steep cut slopes within thick residual soil is common within this region of Indiana. All measured slopes within this cluster of landslides range from 22° to 28°, which corresponds to 2.5:1 to 2:1 horizontal to vertical slopes.

The two primary landslide clusters are within relatively hilly terrain and correspond to the Crawford and Dearborn Upland Physiographic Regions. Figure 12 illustrates topography respective of the Crawford and Dearborn Upland Regions and seems to indicate that topography is a function of landslide occurrence, as might be expected. However, closer examination reveals that landslides do not occur within the hilly terrain east of the Crawford Upland Region, within the Norman Upland Region.

Clearly landslide occurrence is not just a function of topography. Considering bedrock geology of the physiographic regions, the Crawford Upland Region is composed of the Raccoon Creek, Stephensport, West Baden, Buffalo Wallow and Blue River bedrock groups. These bedrock groups are composed of alternating layers of shale, limestone and or dolomite, with shale being a significant constituent. The Norman Upland Region is composed of the Sanders and Borden bedrock groups. These groups contain mostly siltstone and limestone, with shale as a minor constituent. Figure 13 illustrates this fraction in bedrock composition respective of landslide occurrence.

As observed in Figure 12, there are several landslides that occur just to the east of the Crawford Upland Physiographic Region within the Mitchell Plain Physiographic Region. 35 landslides are located within this area, all but 2 of these landslides occur within embankments. Only 3 of the 35 landslides are thought to be earth slump on bedrock landslides, while the landslide classification is unknown for 14 of these landslides. This suggests that bedrock geology is not responsible for these landslides just east of the

Crawford Upland Region. Therefore, generally it is observed that within South Central Indiana landslides are a function of both topography and bedrock geology.

Figure 14 illustrates landslide occurrence in Southeast Indiana within the Dearborn Upland Region respective of bedrock geology. Landslides within the Dearborn Upland Region occur primarily within the Kope and Dillsboro Formations, which are composed mostly of shale. The Kope Formation is predominately composed of clay shale, containing about 5 percent fossiliferous limestone, and the Dillsboro Formation is composed of about 30 percent argillaceous limestone and 70 percent shale (Shaver et al., 1970). The Kope Formation is notorious for the occurrence of landslides in and around Cincinnati, Ohio and is also responsible for many failures within Southeast Indiana and Northern Kentucky. Therefore, landslide occurrence within Southeast Indiana is also function of both bedrock geology and topography. Landslides within the Kope Formation have never been known to penetrate into the bedrock. Failure within this formation usually occurs along the soil-bedrock interface (Gray, 1985).

In an effort to determine the relative susceptibility of each bedrock formation to landslide occurrence, the landslide density within the bedrock formations was calculated. The area of each bedrock formation and group exposed as an outcrop or as the underlying bedrock was calculated within ArcView. From this the landslide density within each bedrock component was calculated; the results are presented in Table 5. The Kope Formation has the highest density of landslide occurrence, 31 landslides per 100 mi^2, followed by the Buffalo Wallow Group, which has a landslide density of 15 landslides per 100 mi^2. The density of landslide occurrence of the Stephensport Group is about 4 landslides per 100 mi^2, followed by the Sanders and West Baden Group at about 3 landslides per 100 mi^2.

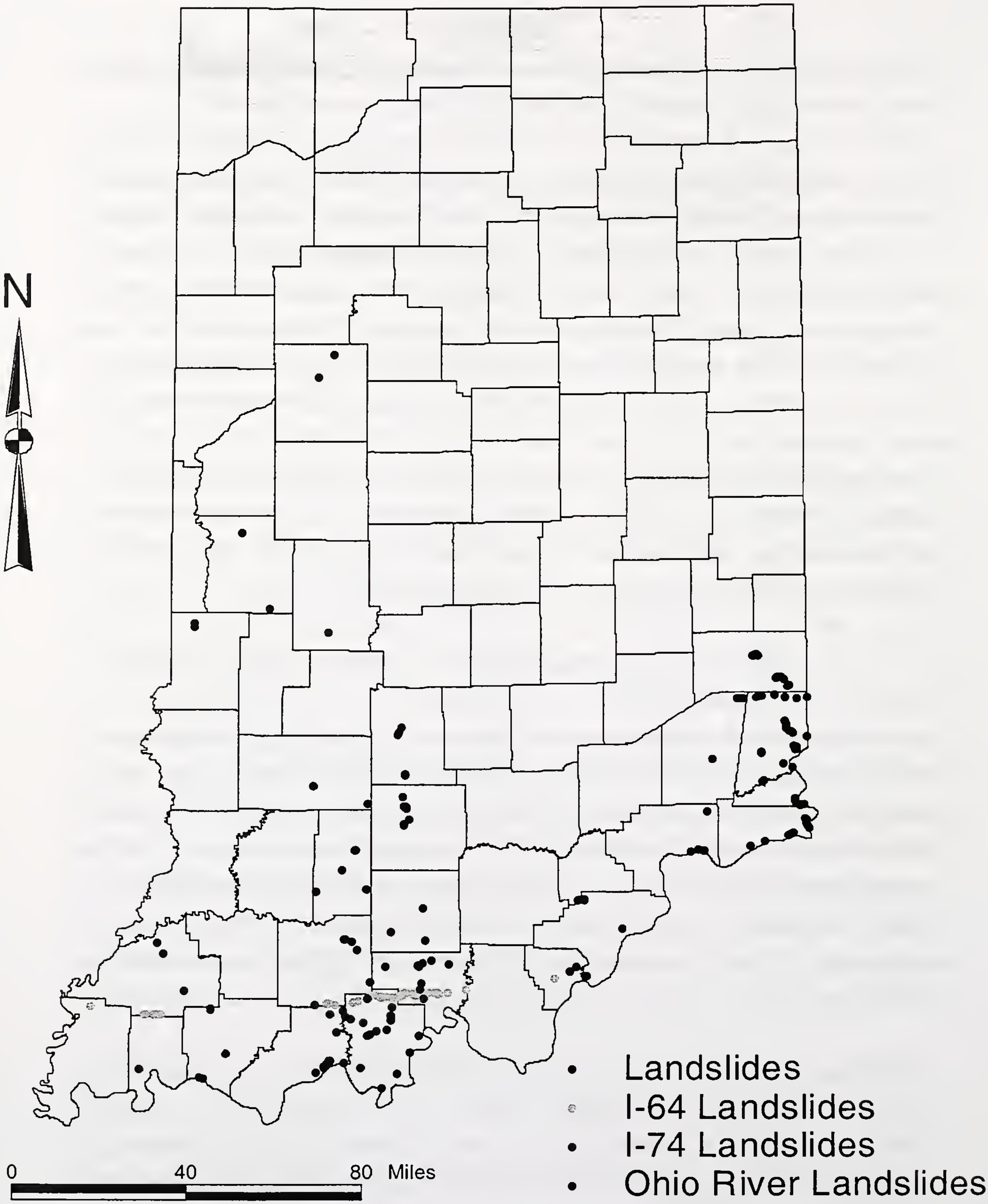

Figure 11. Landslide Distribution Relative to Indiana Roadway Network.

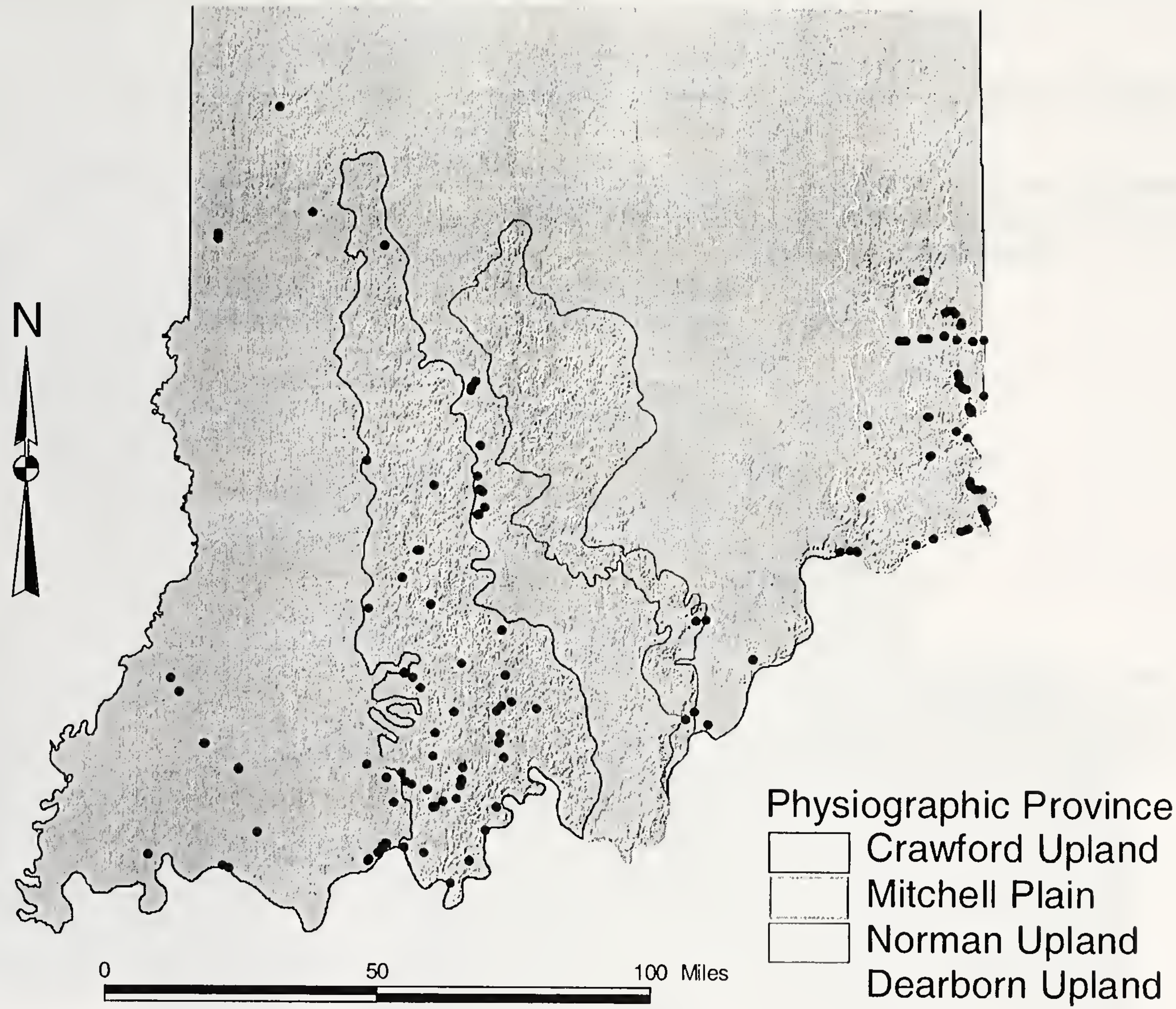

Figure 12. Landslide Distribution Relative to Topography.

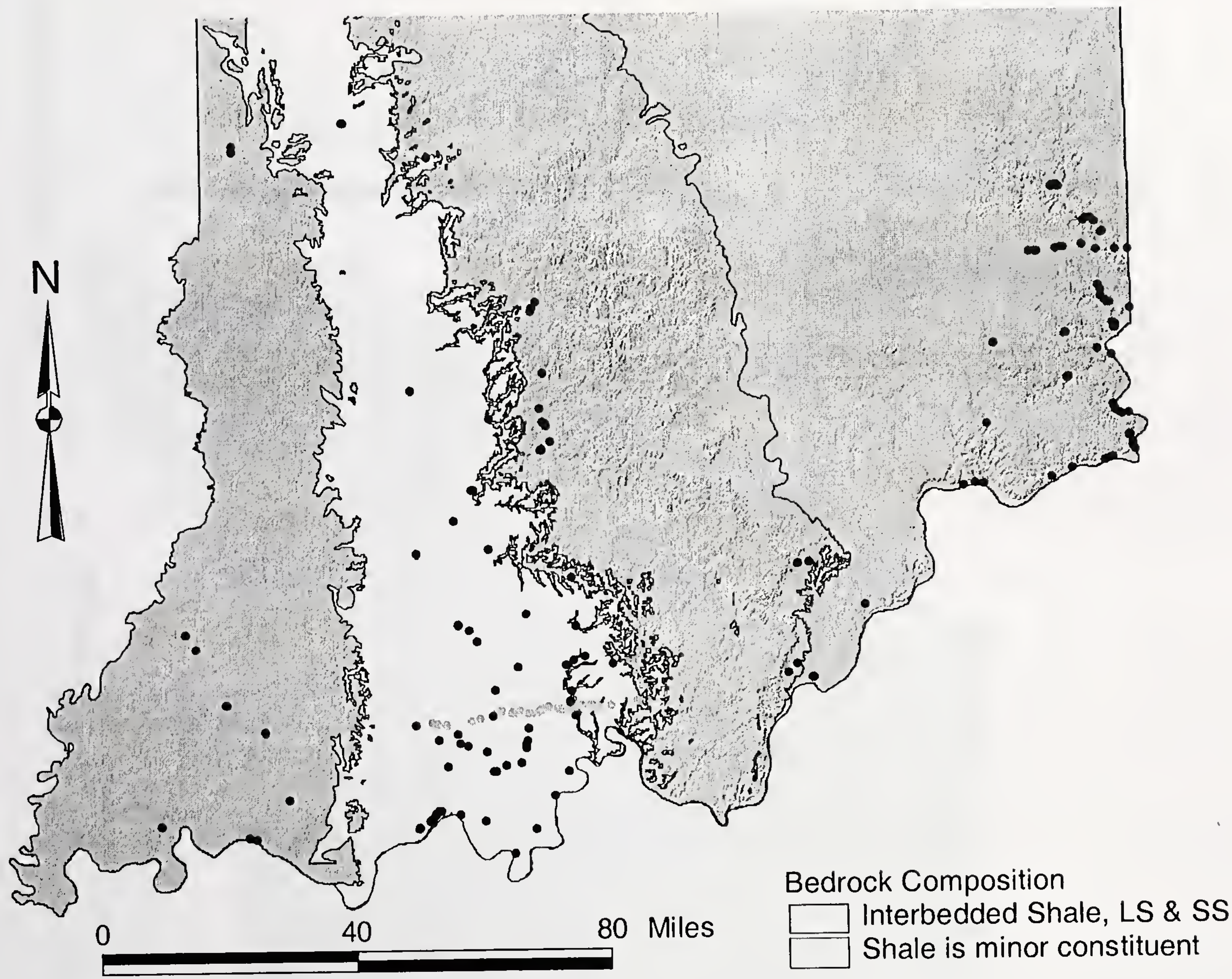

Figure 13. Landslide Occurrence within South Central Indiana Relative to Bedrock Composition.

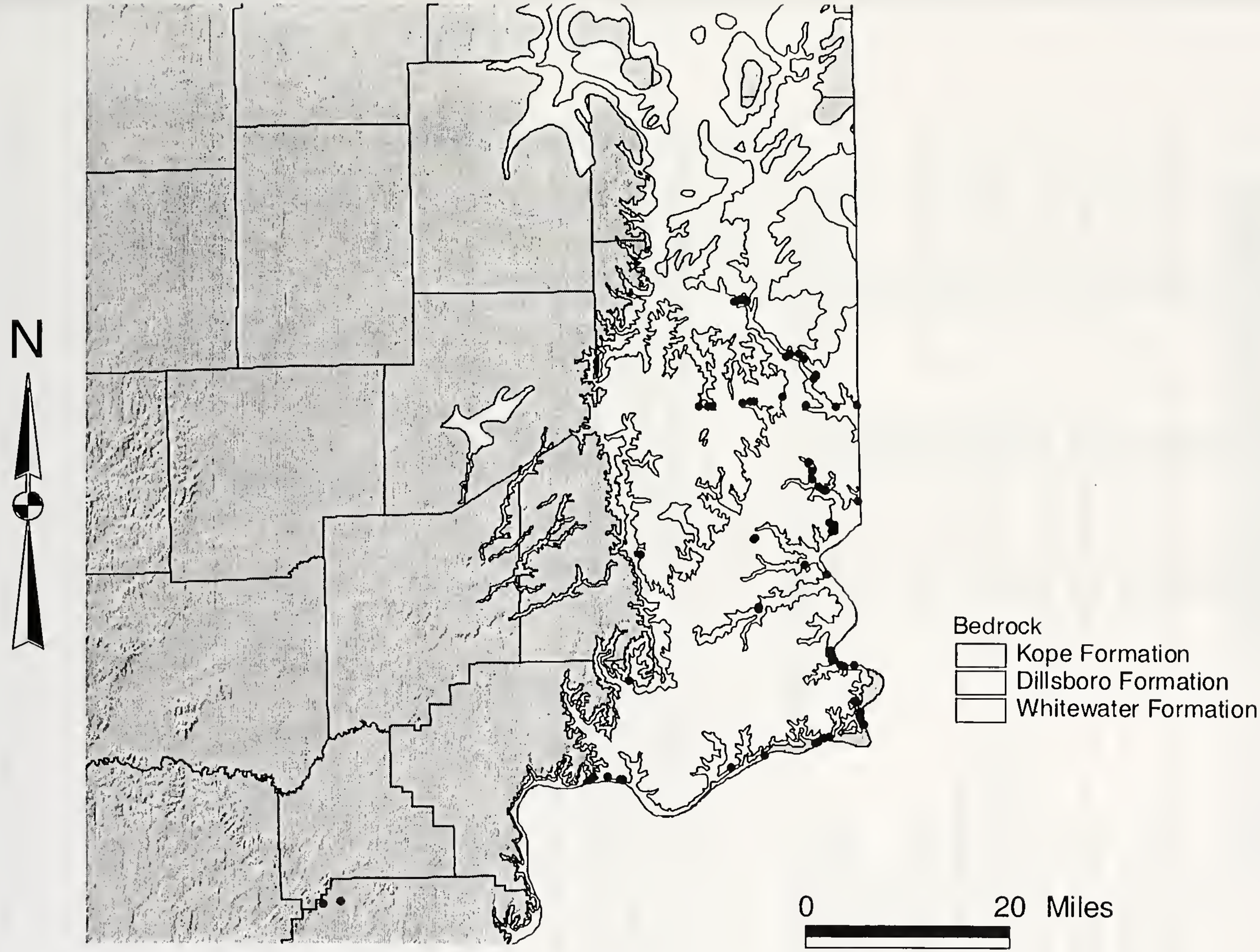

Figure 14. Landslide Occurrence within Southeast Indiana Relative to Bedrock Formation.

Table 5. Landslide Density within Bedrock Formations.

Bedrock Type	Number of Landslides	Bedrock Area (mi^2)	Landslide Density (No. per 100 mi^2)
Kope Formation	38	123	31.0
Buffalo Wallow Group	37	242	15.3
Stephensport Group	18	431	4.2
Sanders Group	21	696	3.0
West Baden Group	14	506	2.8
Dillsboro Formation	21	1092	1.9
Blue River Group	22	1313	1.7
Patoka & Shelburn Formation	28	1774	1.6
Raccoon Creek Group	52	3500	1.5
Whitewater Formation	7	948	0.7
Carbondale Group	10	1562	0.6
Bond Formation	1	340	0.3
Borden Group	9	4338	0.2
Muscatatuck Group	5	4167	0.1
New Albany Shale	1	4001	0.03
Total	284		

So it is seen that landslides within Indiana occur in two primary clusters, South Central Indiana and Southeast Indiana, and that landslide occurrence within each of these areas is shown to be a function of both topography and bedrock geology. The landslide inventory only includes those landslides adjacent to Indiana roadways. Naturally induced landslides not found adjacent to Indiana roadways may be entered into the inventory and GIS database in order to confirm or refine the hypothesized correlation of landslide occurrence with geologic features.

5.0 PROPOSED LANDSLIDE REMEDIAL METHODS

5.1 Overview

The Ohio, Kentucky, Tennessee, and Illinois highway departments were contacted to inquire about the respective state's typical treatment of landslides. An extensive review of literature regarding landslide remedial methods was also performed. In order to learn practical application issues of the proposed methods and to obtain cost estimate figures, contractors and other professionals were contacted. A complete list containing contact information of the highway departments, and also organizations and individuals contributing information regarding the proposed methods is included as Appendix F.

From the review of available and applied landslide remedial methods, proposed methods include: conventional horizontal drains, horizontal wick drains, recycled plastic pins, railroad rail piles, lime cement columns, biotechnical remediation and gravity mass retaining systems. Two of the eight methods proposed involved drainage of some type. Also, three of the eight methods are cantilever pile systems, the difference between each method being the pile composition. All methods can be applied in-situ with the exception of some types of gravity mass retaining systems and biotechnical remediation.

The application of horizontal wick drains is a relatively new concept still within the research and development stages at the University of Missouri-Rolla. Dr. Paul Santi, the principal investigator, has applied horizontal wick drains to a test embankment and also to a landslide in Missouri. He has had favorable results from these applications. The use of driven recycled plastic pins is still within the infant stages of research under the direction of Drs. John Bowders and Erik Loehr at the University of Missouri-Columbia. There are no published results regarding their research, however, Dr. Bowders and Dr. Loehr plan to perform the first full scale slope stabilization using recycled plastic pins late summer of 1999.

5.1.2 General Application Issues of Remedial Methods

Conventional engineering practice utilizes safety factor design and analyses to assess the stability of slopes and for the design of remedial measures. Safety factors equal to

one theoretically indicate a failing condition, and safety factors greater than one indicate a stable condition. To account for the uncertainty within the models and in the determination of shear strength, safety factors significantly greater than 1.0 are generally required. A general, landslide remedial techniques can improve the stability of a slope by either reducing the driving forces or increasing the resisting forces as illustrated in Table 6 and discussed below.

Table 6. Remedial Method Stabilizing Action Summary.

Remedial Method	**Stabilizing Action**	
	Driving Force Reduction	**Resistive Force Addition**
Horizontal Drainage	reduce total weight reduce seepage force	increase effective stress
Cantilever Piles		physical restraint
Biotechnical Remediation	reduce total weight	physical restraint, increase effective stress
Gravity Mass Retaining Systems		phyiscal restraint

Of the proposed remedial methods, the drainage treatments (conventional horizontal drains, horizontal wick drains), reduce driving forces and increase resistive forces. The removal of water reduces the driving force by decreasing the total weight of the soil mass. The water pressure is also reduced such that the effective stress in shear resistance is increased. The cantilever pile methods (railroad rail piles, recycled plastic pins, and lime cement columns), physically restrain the sliding mass and thereby increased the resistive force to sliding. Gravity mass retaining structures place load near the landslide toe, adding resistance to sliding. Biotechnical remediation uses inclusions of vegetation which act similar to reinforcing inclusions of reinforced earth structures to restrain the sliding mass. Also, the vegetation reduces infiltration and when positioned horizontally within a slope, behave as horizontal drains.

The selection and application of remedial methods depends upon the depth to the failure plane, local geology and hydrogeology, engineering characteristics of the material involved, and availability of capable contractors. Also, the selection of a suitable

remedial method requires consideration of the cost-benefit of the remedial action, and a general understanding of the landslide mechanism. Imperative to the stabilization of all landslides is a complete understanding of the global extent of the landslide. There are many cases where soils were excavated or placed to stabilize a slope only to find that the alteration induced instability in a much larger mass. This condition is often associated with pre-existing or relic landslides.

In order to identify and quantify the variables involved in the selection of a remedial method, a geotechnical investigation must be performed. Inclinometers are typically required if there is any uncertainty in the rupture surface geometry. Adequate definition of the rupture surface is a necessary component for efficient design of stabilization schemes. It is not uncommon for very small landslides to be repaired by the excavation and backfill method without conducting a failure investigation. This approach may be adequate in some geologic environments in which there is significant local experience. However, as a general rule, an understanding of the cause of failure is prerequisite to an efficient design of a permanent plan for stabilization.

Within the State of Indiana the excavation and backfill is the most common method used for remediation of smaller landslides, and in most cases, effective in controlling movement. However, there are other remedial methods that may accomplish the same objective at a lower cost. The application and cost of the alternative remedial methods are discussed in the sections that follow. To provide a frame of reference for comparison of costs of the proposed remedial methods, a cost analysis of the excavation and backfill method was performed. Also, a cost inventory of past INDOT landslide remediation projects was performed by Brad Steckler and Tarlochan Bansi, both of the INDOT Engineering Assessment Section, and is included as Appendix D.

5.2 Excavation and Backfill Method

The excavation and backfill method is the remedial method most often applied to landslides by INDOT. Therefore, to be considered, the proposed remedial methods must be less expensive than this method. For comparison, a cost analysis of the excavation and backfill method was performed for three different size idealized landslides- 611 yds^3, 6240 yds^3 and 19420- yds^3, referred to as Case I, Case II and

Case III, respectively. This cost analysis was completed with information provided be the INDOT and a summary is presented in Table 7.

Table 7. Unit Cost for Excavation and Backfill Cost Analysis.

	SCENARIO	Case I 611 yds^3	Case II 6240 yds^3	Case III 19480 yds^3
		Unit Cost (\$/yd^3)		
Excavation in Soil	**1** No. 1 or No. 2 backfill	39	32	23
	2 Rip Rap backfill	37	30	22
	3 No. 1 or No. 2 backfill w/ B-borrow	41	32	22
	4 Rip Rap backfill w/ B-borrow	40	31	21
Excavation in Soil & Rock	**5** No. 1 or No. 2 backfill	50	38	24
	6 Rip Rap backfill	48	36	23
	7 No. 1 or No. 2 backfill w/ B-borrow	52	38	23
	8 Rip Rap backfill w/ B-borrow	51	37	23
	Percentage volume of excavated rock	24.5	9.7	7.3
	Total Cost (minimum)	\$22,837	\$189,700	\$416,095
	maximum	\$31,955	\$235,426	\$462,728

The volume of the idealized landslides are not arbitrary, they are reflective of the range of landslide volumes estimated in the inventory. It was only possible to estimate the volume for 163 landslides in the inventory. The average estimated landslide volume of these landslides is about 6400 yd^3, and ranges from about 100 to 84,000 yds^3. Figure 15 is a histogram of estimated landslide volumes and illustrates that approximately 80% of the estimated landslide volumes are below about 9000 yds^3, and 50% are below 2000 yds^3. Case II is thought to represent the average estimated landslide volume, while Case I is significantly below this average and Case III is significantly above this average.

For each case, there are four different types of backfill combinations that may be used. No. 1 and No. 2 aggregate have the same unit cost and therefore are considered the same throughout the cost analysis. 'B-borrow' is used with aggregate backfill in order to reduce the volume of imported aggregate fill required. 'B-borrow' is simply soil indigenous to the site that is excavated near or within the landslide and compacted

within the fill area. Additionally, for each type of backfill used, excavation either occurs entirely within soil, or partially within bedrock. Therefore, for each case there are eight different scenarios based upon the type of backfill used, and also the type of excavation encountered. Table 7 summarizes each scenario and lists the corresponding unit cost of each.

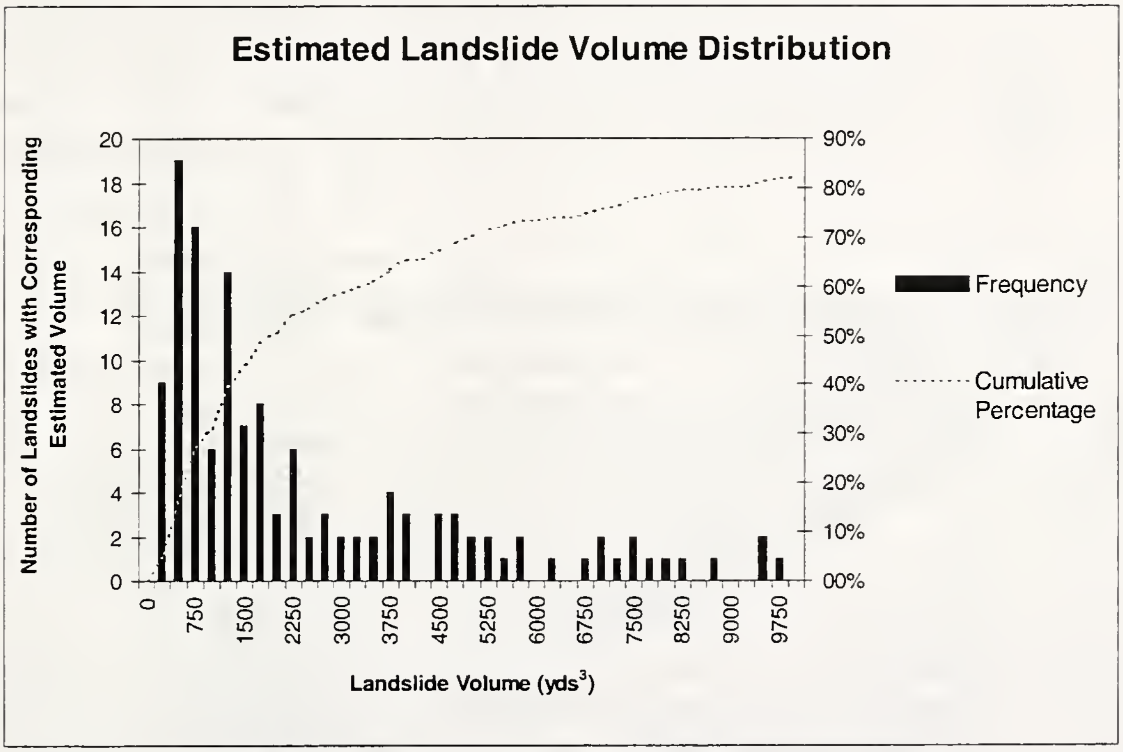

Figure 15. Histogram of Estimated Landslide Volume.

Figure 16 summarizes the unit cost of each scenario relative to the landslide size. As observed, unit cost of repair significantly decreases with increasing landslide volume. Excavation within rock significantly increases the costs of repair for smaller slides, but does not increase the cost of repair for larger landslides. This is due to two reasons; the unit cost for excavating rock decreases with increasing volume of excavated rock, and the percentage of excavation required within rock decrease with increasing total excavated volume. Many slope failures are believed to occur at the soil-bedrock interface, not within the rock mass. As such, ideally bedrock excavation will be required to remove only the weathered, degraded veneer on the top of the bedrock surface.

Therefore, the percentage of required excavation within bedrock compared to the total volume of soil and rock excavated will decrease with increasing landslide volume among landslides within the same geological conditions and profile.

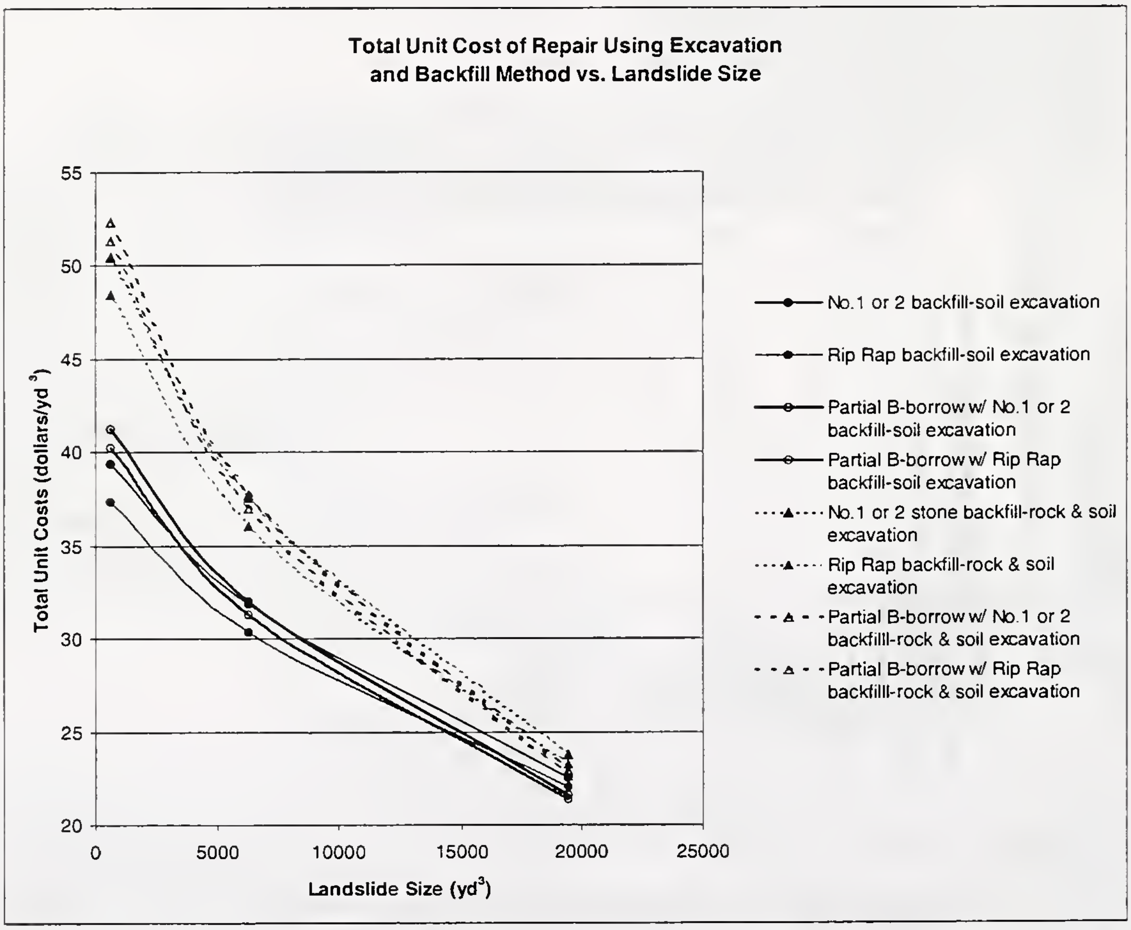

Figure 16. Unit Cost of Repair Using Excavation Backfill Method vs. Landslide Volume.

As observed in Figure 16, cost savings using 'B borrow' material is not realized until the excavated volume exceeds approximately 6,000 yd^3. This may be because 'B-borrow' material must be compacted much more thoroughly compared to granular backfill. The time and equipment costs required to properly compact 'B-borrow' material exceeds costs required to import granular fill until the volume of fill exceeds approximately 6,000 yds^3.

A cost inventory of INDOT landslide remediation projects was performed by Brad Steckler and Tarlochan Bansi of the INDOT Engineering Assessment Section, and is included as Appendix D. The cost inventory includes cost records for 31 landslide remediation projects from 1972 to the present. Because costs are not adjusted to account for inflation, only project cost within the last ten years were considered. The average costs of five projects that used the excavation and backfill method was approximately $1,130 per foot of correction, and ranged from $517 to $2,442 per foot of correction. The estimated average from the cost analysis is $900 per foot of correction. Table 8 summarizes the range and average cost per foot of repair of the excavation and backfill method as determined by the performed cost analysis and the INDOT cost inventory.

Table 8. Excavation and Backfill Cost Summary.

	Cost Analysis	***INDOT Cost Summary***
	(Cost Per Foot of Correction)	
Case I	$228(min) $ 320 (max)	-
Case II	$998 (min) $1,239 (max)	-
Case III	$1,486 (min) $1,653 (max)	-
Minimum	$228	$517
Maximum	$1,653	$2,442
Average	$900	$1,130

5.3 Drainage

5.3.1 Overview

It is generally agreed that groundwater is the single most important cause of the majority of landslides (Holtz and Schuster, 1996). Thus, it would seem that draining water from a slope is the single most effective remedial technique that may be applied. Water not only adds weight to the soil, but also reduces effective stress and accelerates weathering of rock and soil, softening and weakening rock and soil. Although drainage can always improve the stability of a landslide, drainage may likely be most effectively utilized to prevent landslides. After significant strain has occurred, soil and/or the soil-bedrock interface strength is often reduced to the residual strength. Groundwater near the soil/bedrock interface is considered the major cause of earth slump on bedrock landslides in Indiana. Because of this, drainage treatments are considered within the proposed remedial methods.

Drainage may be used as the sole remedial technique, however it is most often used in conjunction with other remedial methods. There are many techniques that can be applied to drain water from within a slope. Drainage systems can operate either internally or externally. Internal drainage systems directly control or reduce groundwater levels. External drainage systems act indirectly to reduce groundwater levels, by reducing infiltration or channeling overland flow from the slope. A landslide successfully stabilized using drainage almost always facilitates more than one method of drainage. Internal drainage systems must be used to control groundwater and external drainage must be applied to reduce infiltration.

Internal drainage facilitates drainage by means of an intrusive inclusion such as horizontal and vertical wells or trench drains. Drainage methods may be a variety of sizes and positioned vertically or horizontally, and include, conventional horizontal drains, wick drains, vertical wells, large diameter vertical drainage wells or galleries, and drainage tunnels. Horizontal drainage systems utilize gravity flow and vertical wells require pumping. Drainage systems requiring pumping incur additional liabilities due to utility costs and required maintenance to mechanical equipment. Horizontal drainage systems are not without maintenance needs, however they usually have an advantage in

terms of both cost and maintenance requirements, but they do require proper construction and filter design to assure long term operation.

Vertical wells are used where the depth to groundwater is such that trench drains prove uneconomical. Vertical wells are positioned within and around landslide areas, and if large enough, may allow horizontal drilling within the well to connect adjacent vertical wells in a manner that allows gravity drainage of each vertical well to single or multiple points where water is pumped and removed. Vertical wells may also be closely spaced and overlap at belled bases. This method has been used to stabilize large landslides along roadways in California and Kentucky (Holtz and Schuster, 1996). Where vertical wells prove uneconomical due to large depths to groundwater, drainage tunnels may be used (Holtz and Schuster, 1996). Large diameter drainage wells and tunnels are expensive and are typically applied only to very large landslides requiring drainage of an extensive area.

External drainage systems act indirectly to reduce groundwater levels by reducing infiltration, and are especially effective in reducing short-term infiltration during periods of intense and/or consistent precipitation. External drainage systems include interceptor and diversion ditches, and vegetation. INDOT often installs a concrete paved interceptor ditch (CPID) near the crest of cut slopes to divert overland flow from the slope crest. Erosion parallel to CPID's between the drainage structure and soil often occurs and may open infiltration paths within the soil mass acting counter to the intention of the design and thereby reduce stability. Figure 6 is a photograph showing erosion along a CPID that likely contributed to instability.

Erosion can also occur near the toe of a landslide due to natural or man made drainage features. Whether a perennial stream, intermittent stream, or drainage ditch, during periods of intense or continuous precipitation, water flowing at the toe of a landslide may erode soil, which may lead to instability. Figure 17 is a photograph showing erosion at the toe of a landslide due to a small ditch running parallel to the base of the slope.

Vegetation is also used in remedial practice to control infiltration. When used to prevent erosion or remediate shallow surface sloughing, it is termed biotechnical remediation. Vegetation reduces soil moisture through evapotranspiration, impedes runoff, and also

reinforces soil with the roots of the plant. Biotechnical remediation is discussed in detail in section 5.6.

Figure 17. Erosion along riprap lined drainage ditch at toe of landslide on SR 450, 8.6 miles northeast of US 50 in Martin County.

5.3.2 Horizontal Drainage Overview

Within Indiana, groundwater flowing along the soil-bedrock interface is considered the major contributing cause of instability among earth slump on bedrock landslides. Water at the bedrock-soil interface accelerates weathering of rock, weakens soil, and reduces effective stress. Draining water from this area is the single most effective measure that can be undertaken and horizontal drainage can be very effective in draining water from the soil-bedrock interface. However, long-term performance of horizontal drains depends on several factors such as frequency and quality of maintenance program, type of pipe casing used, pH and mineral content of groundwater, lithologic characteristics of the site, and measures taken to protect drain outlets (Smith, 1980).

Horizontal drains are susceptible to clogging due to precipitation of chemicals from groundwater, vegetation growth near drain outlets, build up of biological phlegm, and also may clog due to 'silting' or migration of fines into the drain pipe (Brauns and Schulze, 1989). Routine maintenance may be required to insure flow is not hindered and to clear clogged drains. Experience in California dictates that most horizontal drains need to be cleaned once every 5 to 8 years. The California Division of Highways (CDH) often uses solid sections of pipe near the final 6 feet of pipe to discourage plant growth to prevent clogging. Also, drains must be cleaned more frequently when they are placed in very fine-grained soil or in areas of heavy root growth (Holtz and Schuster, 1996).

Because horizontal drains are susceptible to clogging, skepticism exists within the professional community upon the long-term effectiveness of horizontal drains. Regardless, horizontal drainage can be an effective stabilization measure and also the most cost-effective remedial measure that may be taken.

5.3.2.1 Conventional Horizontal Drainage

Conventional horizontal drains were first applied to stabilize landslides in California in 1939 and incorporated steel pipe (Smith, 1980). Steel pipe is now widely discouraged for use as horizontal drains due to the materials' susceptibility to corrosion. Today, polyvinyl chloride (PVC) pipe, is typically used for horizontal drains. Experience of the CDH dictates a maximum design life of about 40 years for steel pipe. PVC cased drains are expected to exceed the design life of steel cased drains (Smith,1980).

Most mechanical landslide treatments incorporate drainage in some aspect in order to reduce excess pore pressures from behind the retaining structure. Horizontal drainage is also applied as the sole landslide treatment. The West Virginia Department of Transportation often applies temporary physical restraint at the landslide toe to raise the safety factor to just above one, while installed drainage has time to take effect. Temporary restraints include gabion buttresses, earth and riprap fills, and also steel or wood cantilever piles. The Kentucky Transportation Cabinet (KYTC) and the Tennessee Department of Transportation (TDOT) often use conventional horizontal drainage to stabilized landslides. Jensen Drilling, a specialty contractor, is often employed by KYTC

and TDOT to drill and install horizontal drains. Jensen Drilling's standard procedure for horizontal drain installation is as follows.

A dozer-mounted drill is positioned perpendicular to the face of the slope. A 4 1/8" hole is advanced at the desired inclination to the design depth using conventional rotary drilling techniques. An expendable drill bit is attached to 3 1/2" drill rods. After completion of the drilling, 1 1/2" slotted schedule 80 PVC is installed through the drill rods. The drill bit is then removed, and the drill rods are withdrawn, leaving the PVC in place. Standard pipe slot width is 1/10,000". Two rows of slots are positioned on the pipe crown 120° apart. The slot density is 44 per foot per row, totaling 88 slots per foot of pipe.

Conventional horizontal drains may be installed in parallel fashion or in a fan pattern. Installing horizontal drains in a fan pattern is done in order to reduce the number of drill pads that have to be cut into the slope minimizing the time needed to complete drain installation. Typically, TDOT installs horizontal drains with a 5 to 10 degree slope in parallel fashion spaced 25 feet on center. Horizontal drain spacing may vary from 15 to 50 feet, depending upon the soil involved. TDOT still has many 15 to 20 year old functioning horizontal drains. Drains older than 25 years are typically clogged or are broken due to movement of the slide mass, however some are still functioning.

The unit cost of installed drain is approximately $9 to $11 dollars per foot. Per experience of TDOT, cost may increase to $10 to $15 per foot due to site accessibility problems, and may escalate to $15 to $20 per foot if water has to be imported for drilling because no nearby water source exists.

5.3.2.1 Horizontal Drainage using Wick Drains

Wick drains are flat, geotextile-coated plastic channels that are commonly installed vertically to accelerate settlement. They were originally developed in the 1930's and became more popular in the 1970's when durable plastic replaced the cardboard channels originally used. The application of horizontal wick drains is a relatively new concept still within the research and development stages under Dr. Paul Santi at the University of Missouri-Rolla.

The installation technique is as follows: a jackhammer, hydraulic shovel, bulldozer or trackhoe works from a prepared platform cut in the slope to push small diameter steel pipe into the slope. The annulus of the steel pipe is preloaded with wick drain, which is attached to a disposable drive cone at the advanced end of the pipe. Figure 18 is a photograph showing the disposable drive cone and wick drain. After the loaded steel pipe is pushed or driven to target depth, the steel casing is removed, abandoning the disposable drive cone and leaving the wick drain.

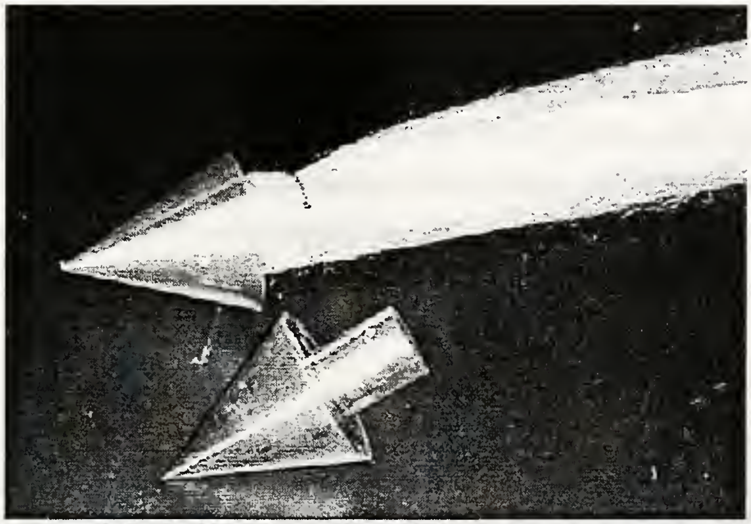

Figure 18. Disposable drive cone and wick drain **(Santi, 1999).**

Horizontal wick drains have been successfully controlled water levels of a test embankment in Missouri. Figure 19 is a photograph of the test embankment showing the installed horizontal wick drains. The embankment was instrumented with six piezometers and 16 soil moisture meters. The wick drains were installed in a fan patter, and results show the drains are effective in controlling long-term groundwater levels and short-term infiltration near the face of the slope where the drains are in a tight pattern. The drains are less effective controlling short-term infiltration higher on the slope where the drains were more widely spaced and deeper in the embankment. It was concluded from the field test that the wick drains are effective in controlling long-term groundwater levels in natural slopes and fill embankments. Also, to successfully control short-term infiltration, shallow drains should have a closer spacing than deeper drains.

Wick drains have also been installed in an instrumented landslide near Booneville, Missouri, however, results are yet to be published. Cost of wick drain installation based on the Boonville landslide are $3-$5 per foot, using equipment operators without prior experience of wick drain installation. The cost of wick drain installation is expected to decrease as the installation crew gains experience.

Preliminary results from field application of wick drains show that they may be applied to control long-term water levels and short-term infiltration in natural slopes and fill embankments. Though the degree of effectiveness in controlling groundwater levels depends largely upon the soil drainability, it is believed that wick drains may be applied to any natural or fill embankment slope of any soil type. Attempts to stabilize another landslide in Missouri and also in Colorado using horizontal wick drains are scheduled during the summer of 1999. Wick drains have yet to be applied to earth slump on bedrock landslides, however wick drains will be applied to an earth slump on bedrock landslide in Colorado during the summer of 1999.

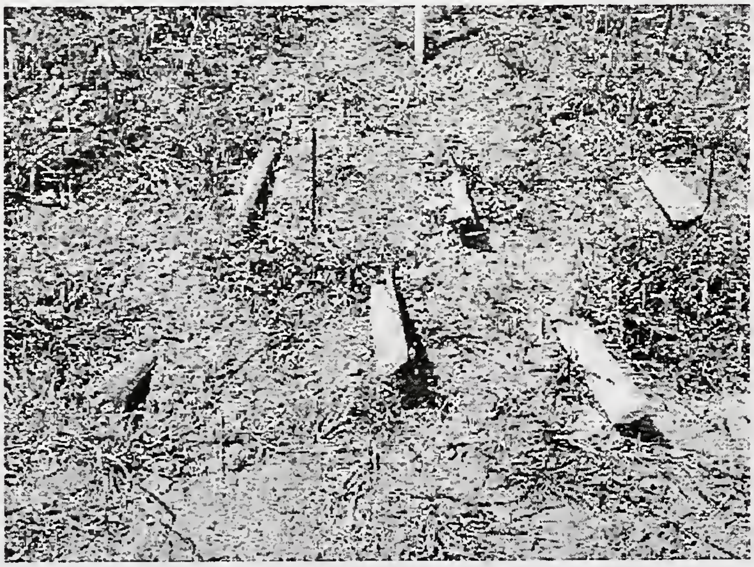

Figure 19. Test embankment with six horizontal wick drains **(Santi, 1999).**

5.4 Cantilever Piles

Predrilled or driven steel piles, cast in place concrete piles, precast concrete piles, predrilled railroad rails, and timber piles may be installed within the slope to retard soil movement. Driven piles either placed contiguously or closely spaced can be effective in stabilizing shallow landslides and anchored or bored pile walls have been successful in stabilizing deep-seated landslides (Morgenstern, 1982). Unanchored pile or pier systems are seldom recommended for depth to failures greater than 18' due to design limitations. Restraint of deep-seated landslides are best obtained using some type of active anchorage system such as a tied back wall.

Soil arching between adjacent piles prevents soil movement between piles. Lagging may be incorporated between installed piles to increase the confining effect of the system. Load is transferred from the length of pile within the moving wedge of soil to the length of the pile embedded in competent material facilitating cantilever action. As a general approximation, the length of pile embedded within competent soil or rock is typically greater than 1/3 the total length of pile.

Based on local experience within the Ohio River valley, drilled pier walls are typically constructed with 18" to 30" inch reinforced concrete piers spaced 5 to 7 feet on center where the depth of failure is less than 20 feet (Nethero, 1982). Nethero also states that designs using drilled pier walls are usually limited by the strength of the competent material below the failure plane. The costs associated with construction of drilled pier walls are comparable to the costs of other reinforced concrete structures (Nethero, 1982).

Traditionally, the application of pile and pier structures for landslide stabilization have been reserved for high risk situations, were high costs are justified (Hausmann, 1992). However, the cantilever pile techniques discussed are not traditional remedial treatments, and are less expensive to apply than traditional pile structures.

5.4.1 Lime Piles and Lime Cement Columns

Lime piles and lime cement columns both rely upon lime to stabilize the soil, however, each method delivers lime into the subsurface by different methods. Lime piles are bored holes backfilled and compacted with quicklime. They are different from lime cement columns, which are columns of mixed soil, lime and cement that require in-situ mixing techniques.

Lime has often been used to stabilize soft soil. Cation exchange and stabilization within the clay facilitated by the addition of lime are the basis of the treatment. Cation exchange begins after the addition of lime and causes clay particles to flocculate, changing it's plastic characteristic to a more friable one, increasing the strength. Stabilization occurs over time and is caused by the crystallization of calcium silicate hydrate and calcium aluminate hydrate gels that form following dissolution of clay minerals in a high PH environment (Rogers and Glendinning, 1997(a)).

Lime piles have been used to stabilized shallow slope failures due in part because an increase in effective cohesion has a relatively large influence on the stability of shallow seated failures. Lime piles are typically installed in a grid patter at a density and diameter sufficient to raise the factor of safety to the desired level. A paper by Roger and Glendinning, 1997(b) outlines recommended design guidelines for slope stabilization using lime cement columns. The authors state that lime piles stabilize by the following distinct mechanisms.

- Generation of negative pore-water pressure caused by quicklime in the piles drawing in water from the surrounding soil;
- Increased strength of the clay in the shear zone from overconsolidation of the shear plane or zone due to the increase in effective stress as a consequence of the negative pore-water pressure;
- Increase in pile strength due to progressive hydration and crystallization of the lime;
- Increased strength of the clay in a small annular zone surrounding the piles due to migration of calcium and hydroxyl ions and a subsequent lime-clay reaction.

Standard design procedures addressing the specifics for the application of lime piles for slope stability are available in literature and are not covered here. Rogers and Glendinning, 1997(b) describe design parameters and other considerations for lime pile stabilization. A brief outline of design procedure for the application of lime piles from this paper follows.

1. The failed slope is analyzed using traditional slope stability analysis.
2. Effectiveness of treatment. A desired factor of safety is selected and the treatment is adjusted so that it may be met. Piles should be designed to pass through all slip circles possessing a marginal factor a safety.
3. Are lime piles a suitable treatment? Lime piles are most effective in stabilizing shallow landslides. Lime piles are less effective when applied to deep seated failures.
4. Pile intensity, which is the spacing, number, and position of the rows of piles, is decided. Often, the pile diameter is dictated by available equipment.
5. Compare initial worst-case factor of safety and the improved factor of safety to see the degree of improvement.
6. Define specific design parameters.

Lime cement columns can stabilize soft clay or loose sand mixing lime and cement with indigenous material by a dry, air-driven process, that was developed in Scandinavia during the past 25 years and more recently in Japan. About 6 million linear meters of columns are installed annually in the Scandinavian countries. Stabilator USA, Inc. is a specialty contractor in lime cement column design and construction, and is new to the United States. Although this process has recently been practiced in the United States for foundation soil improvement for embankments and other structures, no specific examples were found in the literature concerning the application to landslides. However, lime cement columns may be applied to remediate landslides.

Indigenous material is mixed with unslaked lime(quicklime) and cement in proportions suitable for the particular application and injected under air pressure varying from 30 psi to 120 psi, depending on the depth of the column. The mixing tool used to accomplish this is usually 0.8 meters in diameter. The strength of the resulting column depends upon several variables.

- Type of indigenous soil. Granular indigenous material will produce a column of greater strength than organic soils.
- The water/cement ratio used.
- The strength provided by the hydration and hardening of the injected cement.
- The strength provided by the pozzolanic-like reaction between the lime, cement and clay.
- The strengthening effects of water content reduction of the soil as water becomes bound by the lime and cement.
- The effects of ion exchange reactions of the clay minerals.

Lime cement column application is most appropriate when modest strength and modest cost are desired and where sufficient water is present in the ground to hydrate lime and cement. Also, lime cement columns can only be installed to a depth of 82 feet due to limitations of installation equipment used by Stabilator USA, Inc. The unit cost of lime cement columns is published as $45 per cubic meter to $65 per cubic meter (Esrig and Mac Kenna, 1999). The general cost figure considered by Stabilator USA, Inc. is about $10 per foot of lime cement column.

5.4.2 Recycled Plastic Pins

The use of driven 4 inch by 4 inch recycled plastic pins (RPP's) for landslide stabilization is still within the infant stages of research under the direction of Drs. John Bowders and Erik Loehr at the University of Missouri-Columbia. The application is similar to micropiles and work is under way to modify conventional design and construction technique that will account for the strength, ductility and creep differences of plastic materials compared to concrete or steel.

RPP's most likely cannot be driven to an adequate depth within bedrock for earth slump on bedrock landslides, but are best suited for minor earth slump landslides that occur at a sufficient distance above bedrock to provide adequate embedment of the plastic pins in competent soil. Dr. Bowders and Dr. Loehr plan to perform the first full scale slope stabilization using recycled plastic pins late summer of 1999. If successful, recycled

plastic pins may provide an attractive economic solution for the stabilization of minor earth slumps.

5.4.3 Railroad Rail Piles

Railroad rails are installed in a row or rows of predrilled vertical holes that are backfilled with aggregate or grout after placement of the rail, and are typically used to remediate landslides occurring in side hill cut/fill sections within hilly terrain, where the landslide scarp surfaces within the roadway. Railroad rails are installed parallel to the road near the shoulder to allow easy access for truck mounted drill rigs. Because rails are typically installed next to the shoulder of the roadway, they do nothing to prohibit movement of the soil mass down slope of the installed rails. Care must be taken to protect the retained soil mass from erosion after movement of the soil mass down slope from rail pile wall exposes the retained soil mass. Used guardrail is often incorporated as lagging to prevent erosion of the retained soil mass.

Railroad rail piles are a common landslide treatment used by the Kentucky Transportation Cabinet (KYTC). In the past, KYTC would drive railroad rails to refusal, however, experience showed that often driven railroad rails did not acquire adequate embedment in bedrock when stabilizing earth slump on bedrock landslides, which resulted in continued movement of the soil mass.

An Excel spreadsheet program written by the KYTC is provided on the disc in Appendix A. Also, “Guidelines for Railroad Rails Used as Retaining Structures”, a KYTC internal publication, is included in Appendix E. Empirically based design charts included in the KYTC design guidelines are based upon the following variables: the gauge of railroad rail used, the depth to rock or the depth to the observed failure surface, the spacing of the rails, and the number of rows of rail used. Railroad rails are furnished in 39 feet sections and design guidelines require 1/3 of the length of the incorporated railroad rail penetrate into bedrock or below the observed failure surface. Given these requirements, the KYTC suggests railroad rails should only be used where the depth of failure plane is less than 23 feet. Therefore, this method is only applicable to landslides with a depth to failure surface less than 23 feet where the railroad rails are to be installed. Also, as mentioned previously, railroad rails are only applicable to road embankments where the

distance of the surfacing scarp in the roadway to the shoulder is less than the depth of failure surface where pile embedment will occur.

Railroad rail pile installation costs are $12 to $14 per foot installed for contractor provided rails. To reduce costs, KYTC will often furnish rails, lowering installation costs to $8 to $10 per foot. KYTC has had success with this method and the Tennessee Department of Transportation (TDOT) is currently collaborating with KYTC regarding the application of railroad rail piles.

5.5 Gravity Mass Retaining Systems

Gravity mass retaining systems stabilize landslides by means of loading the landslide toe. The systems considered include gravity retaining walls, mechanically stabilized earth walls, and tieback walls. Gravity mass retaining systems are utilized whenever limited right of way is available to grade embankment fills and cut slopes to the required slope geometry to maintain a sufficient safety factor.

Gravity retaining walls can be constructed of gabion baskets, rock or riprap, reinforced concrete, or masonry. Conventional gravity retaining wall design utilizes the residual friction angle of fill, which requires designs to compensate substantial lateral force from the fill. A wall height of 10 meters is the upper limit of conventional gravity retaining walls (Morgenstern, 1982). Because of this, conventional gravity retaining walls are limited to smaller slides and are seldom effective in controlling larger landslides (Schuster and Fleming, 1982; Morgenstern, 1982).

Mechanically stabilized earth (MSE) walls first became a popular application to highway construction in the 1970's. The modern concept of soil reinforcement was first developed by Henri Vidal in France and patented throughout the world as "Reinforced Earth," generically called mechanically stabilized earth (MSE). The most popular application of reinforced soil is retaining walls. Geogrid, a geosynthetic grid composed of high-density polyurethane (HDPE), is the most commonly used reinforcement in MSE walls. MSE walls require granular backfill in order to develop adequate interface frictional force between the reinforcement and backfill. Geogrid can be used with a variety of wall facing elements. The most popular wall facing element used is any

variety of precast concrete paneling. Gabion baskets, which are rock filled steel cages, are also used as wall facing.

MSE walls are more flexible than conventional rigid wall retaining systems such as concrete gravity walls. They can endure much more deformation and in fact require strain to develop the frictional force between the reinforcing inclusions and soil fill necessary to resist movement. Also, MSE walls may be constructed to heights much greater than conventional gravity retaining walls. Cost of MSE walls vary depending upon the wall facing used, but vary from $15 to $35 dollars per square foot of wall facing.

Tieback walls are steel H-pile or reinforced concrete pile or pier walls that are anchored with steel tendons, called tiebacks, behind the slip plane of the slope. The pile wall is placed vertically and extends through the sliding mass, past the rupture zone, and is embedded within the underlying competent soil or rock mass. Wall facing between piles may be concrete or precast concrete panels, shotcrete, stone or other construction material. Tiebacks are installed in rows of predrilled holes as soil is excavated from the down slope side of the pile wall, and extend beyond and failed mass, and are anchored within undisturbed material by injecting grout. After the grout has dried, the tieback is tensioned to a predetermined stress level. Tensioned tiebacks increase the normal effective stress acting on the failure plane of landslide. Tieback walls may be more expensive than other methods, but are often the only method that may be used to effectively stabilize large landslides.

5.6 Biotechnical Remediation

Biotechnical remediation, also called bioengineering, is the use of live plants in slope stabilization, stream bank stabilization and is most often incorporated in retaining structures and revetments to improve stability and also to enhance appearance. Live plants are imported to the job site, or are collected from the vicinity and are purposely arranged and embedded in the ground to resist surficial erosion and to prevent shallow mass movement.

This method is not new, the use of plants for erosion control is centuries old. A decade ago, the application of biotechnical remediation was non-existent in the United States,

however, the application of biotechnical remediation in the United States is now commonplace. Biotechnical remediation is driven by regulators because it is considered to minimize environmental impact, and because of the aesthetic appeal, is encouraged by community. Most importantly, biotechnical remediation is a viable engineering solution for erosion control and to prevent shallow sloughing.

Vegetation acts in a variety of ways to improve slope stability- through root reinforcement, and by reducing infiltration through evapotranspiration, and also impeding run off by intercepting rainfall. Immediate reinforcement is gained from woody stems embedded in the ground that act as tensile inclusions. Stability is increased with time as rooting occurs from the vegetation. Embedded brush layers may also act as horizontal drains or wick drains to alleviate excess pore pressures from the slope or structure. Additionally, vegetation adds aesthetic appeal to remediated areas.

Biotechnical remediation incorporates live plant stakes, which are plant stems cut at a 45 degree angle at the base and driven into the slope. Vegetation will then grow from the top of the stake, which is cut flush before placement. Rows of brush layers can be placed in horizontal lifts as fill construction progresses. Often, brush layers are used in place of secondary reinforcing strips within MSE structures. Secondary reinforcement within MSE structures is included to help resist shallow sliding. Just as geogrid provides reinforcement, brush layers develop frictional resistance with the soil and resist shear, however, the vegetation also acts as horizontal drains to alleviate excess pore pressures and provide drainage.

This method is particularly well suited to arrest shallow slumping caused by poor compaction along the edge of constructed embankments. Often sufficient compaction is not achieved near the edge of the embankment during the building process, which results in a poorly compacted zone along the entire face of the constructed embankment. Deep-seated sliding may require geogrid reinforcement in combination with vegetation (Gray and Sotir, 1995). This method is also often used along stream banks to prevent toe erosion and to quickly re-establish vegetation destroyed or damaged from construction. Riprap is often placed below biotechnically remediated areas at the stream bank toe where the stream bank occurs at an outside bend, where erosion occurs.

As previously mentioned, biotechnical remediation is most often incorporated into traditional retaining structures, but can also be applied solely to remediate surficial landslides and erosion affecting only the top few feet of soil. George Athanasakes of Fuller Mossbarger Scott and May Engineers has five years of experience using biotechnical remediation. Per Mr. Athanasakes, live plant stakes cost $2 to as much as $5 dollars per stake. Live brush layers are estimated to cost $15 to $20 dollars per feet per row. Typical bioengineering treatments cost from $250 to $400 per lineal foot of landslide correction.

6.0 COST SUMMARY

A cost summary table including approximate costs of all recommended remedial methods is included as Table 9. Cost estimates are provided in dollars per linear foot for drainage and cantilever pile methods, and in dollars per square foot of wall facing for gravity mass retaining systems. Because of the different cost units, it is difficult to precisely compare costs of drainage and cantilever pile methods to gravity mass systems. However, generally gravity mass systems are more expensive.

Table 9. Cost Summary.

REMEDIAL SOLUTION	COST			SOURCE
	$\$/ft^2$	\$/linear ft	Cost per ft of repair	
Traditional Remedial Method				
Excavation and Backfill			900	*Tarlochan Bansi (INDOT)*
			1,130	*Cost analysis*
Drainage Remedial Methods				
Conventional Predrilled Horizontal Drains		9-20		*Jeff Jensen (Jensen Drilling)*
Driven Horizontal Wick Drains		*3-5		*Dr. Paul Santi (UMR)*
Cantilever Pile Remedial Methods				
Railroad Rail Piles		8-10 (**12-14)		*John Bowlin (KYDOT)*
Lime Cement Columns		10		*Edward Forte (Stabilator)*
Plastic Pins		Unknown		
Gravity Mass Retaining Systems				
MSE, concrete panels	15-23			*David Wheeler (Wheeler Corporation)*
	27			****Tarlochan Bansi (INDOT)*
Gabions	18-35			*John Wolosick (Hayward Baker)*
Tieback Walls	100			*John Davis (Schnabel Foundation Company)*
Miscellaneous				
Biotechnical Remediation			250-400	*George Athanasakes (FMSM Engineers)*

* cost expected to decrease with experience and optimization of installation technique

** cost if railroad rail furnished by contractor

***supplemental cost information provided with INDOT cost summary of remediation projects (Appendix D)

7.0 LANDSLIDE CLASSIFICATION SCHEME

Applicable landslide remedial methods are dependent upon site conditions, slope geometry, landslide geometry, geologic conditions such as soil type, depth of overburden, the depth of failure plane, and hydrogeologic conditions. Design methodologies of remedial methods and landslide attributes dictate the suitability of the remedial method for each landslide. Many of the landslide attributes required to assess the applicability of the proposed methods are quantified for landslides within the inventory spreadsheet, however, some required attributes, such as soil drainability (permeability), were not quantified. Quantifying soil drainability of each landslide was not possible from available information.

The classification scheme is represented by the flowchart illustrated in Figure 20. Eleven landslide types are defined from the following four landslide attributes included in the landslide inventory.

1. Varnes landslide classification (earth slump or earth slump on bedrock).
2. Depth of overburden or failure surface (depth of overburden is used for earth slump on bedrock landslide and depth of failure plane is used for earth slumps).
3. Slope type (embankment or cut slope).
4. Distance landslide scarp surfaces in the roadway from the roadway shoulder (applicable only for landslides occurring in embankments).

Figure 21 illustrates the aerial distribution of the landslide types. The most common landslide types (Type 1, 3, 4 and 8) are represented as various colored triangles and other landslide types are represented as various colored dots.

Table 10 is a summary of the respective attributes of each landslide type and the number of landslides categorized in each landslide type. Seventy landslides are Type 1, which is an earth slump on bedrock landslide occurring within a cut slope with a depth of overburden less than 20 feet. Most of these landslides occur within I-64 cut slopes (see Figure 21). Twenty-eight landslides are Type 8, which are earth slump slides occurring within an embankment or cut slope having a depth to failure surface between 20 and eighty feet. Twenty-six landslides are Type 1, which are earth slump on bedrock

LANDSLIDE CLASSIFICATION

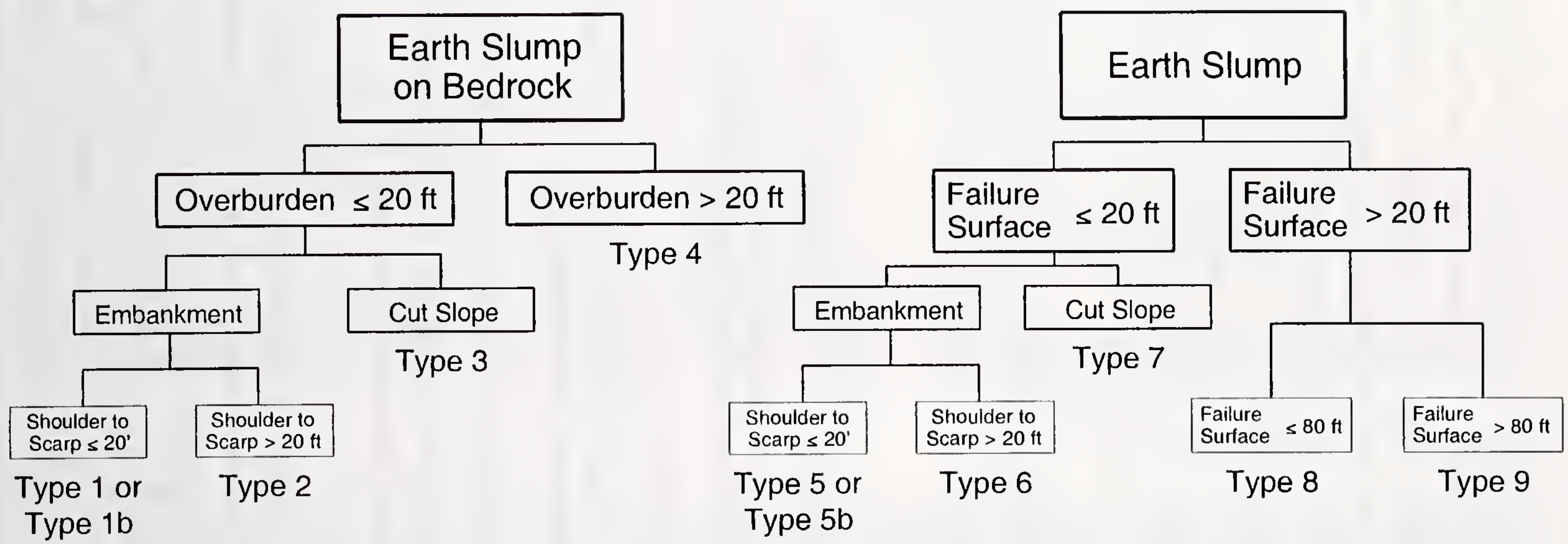

Figure 20. Landslide Classification Flowchart

landslides occurring within embankments with a depth of overburden less than 20 feet. The remaining classified landslides are distributed among, Type 1b, 2, 4, 5, 5b, and Type 7. No landslides are classified as Type 6 or Type 9. The landslide type is unknown for 115 landslides due to lack of information essential for classification. The classification for each landslide in the inventory, including the respective attribute information for which the classification is based, is provided in a summary table in Appendix C.

Table 10. Landslide Classification Summary.

Landslide Type	Slope Type	Varnes Landslide Classification	Depth of OB/FS (ft)	Shoulder to Scarp Distance (ft)	No. of Landslides
Type 1	embankment	earth slump on bedrock	OB[20	[20	26
Type 1b	embankment	earth slump on bedrock	OB[20	•nya	5
Type 2	embankment	earth slump on bedrock	OB[20	>20	2
Type 3	cut slope	earth slump on bedrock	OB[20	••na	70
Type 4	either	earth slump on bedrock	OB>20	na	20
Type 5	embankment	earth slump	FS[20	[20	6
Type 5b	embankment	earth slump	FS[20	•nya	11
Type 6	embankment	earth slump	FS[20	>20	0
Type 7	cut slope	earth slump	FS[20	••na	1
Type 8	either	earth slump	20<FS[80	••na	28
Type 9	either	earth slump	FS>80	••na	0
•••**unknown**					115
				Total	284

• not yet applicable, scarp is below road shoulder
•• not applicable
••• one or more attributes essential for classification is not known

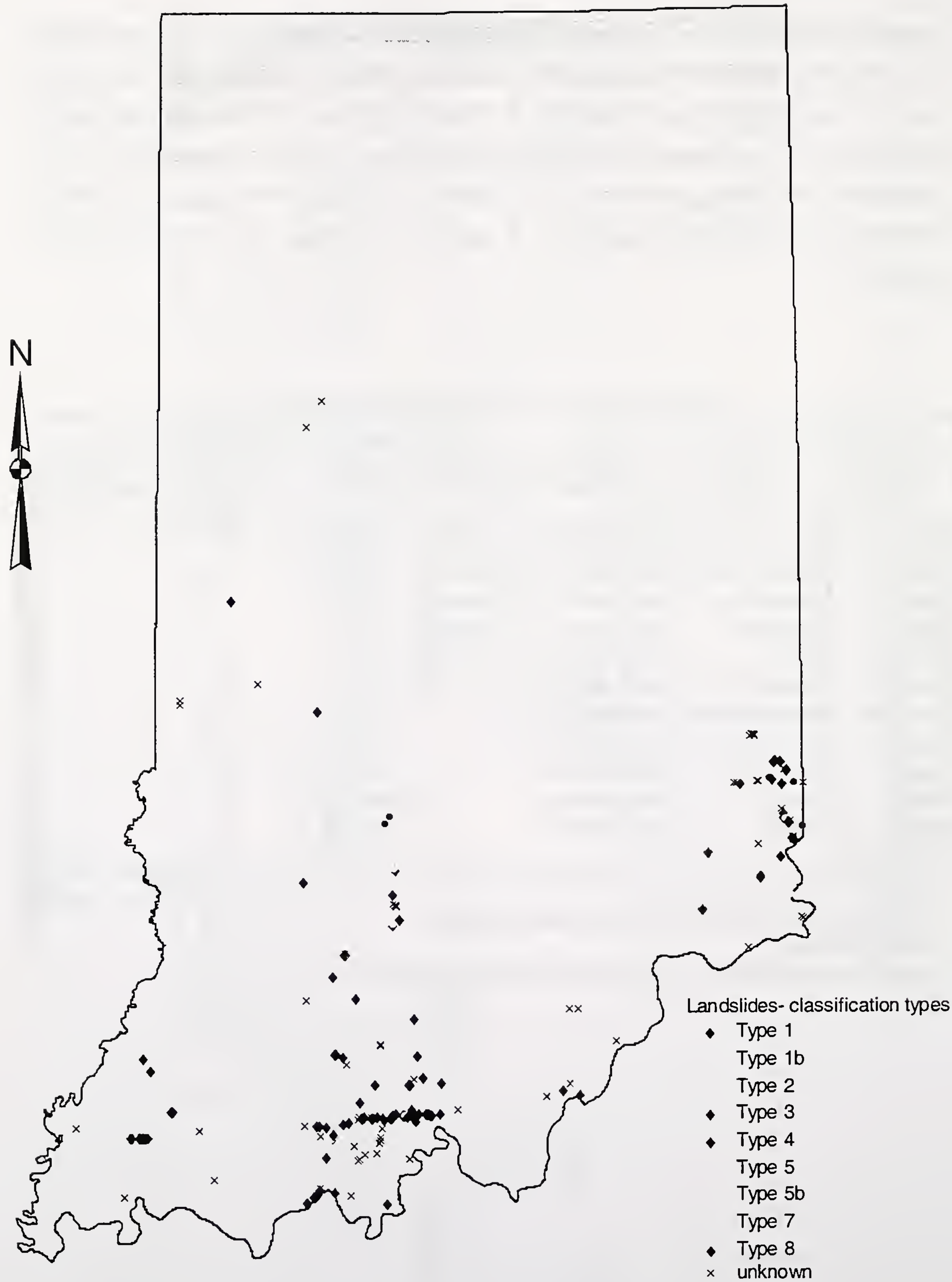

Figure 21. Aerial Distribution of Landslide Type.

Table 11 summarizes, for each landslide type, all applicable proposed remedial methods. As observed, horizontal drainage and biotechnical remediation are not listed in Table 11. Horizontal drainage methods are considered applicable to all landslides. TDOT has successfully applied conventional horizontal drainage in poorly drained soil, however, in highly plastic clays they have not been beneficial. Therefore, proposed horizontal drainage treatments are suitable for all landslides in the inventory unless proven otherwise. Also, biotechnical remediation is usually incorporated with traditional retaining structures and is considered a suitable treatment for landslides in conjunction with the application of gravity mass retaining systems.

Table 11. Appropriate Remedial Methods Respective of Landslide Type.

Landslide Types	***Appropriate Remedial Methods***
Type 1	RR rail piles
Type 1b	RR rail piles
Type 2	Gravity mass retaining systems
Type 3	Gravity mass retaining systems
Type 4	Gravity mass retaining systems
Type 5	RR rail piles, Recycled plastic pins, Lime cement columns
Type 5b	Lime cement columns
Type 6	Lime cement columns
Type 7	Lime cement columns, Recycled plastic pins
Type 8	Lime cement columns, Gravity mass retaining systems
Type 9	Gravity mass retaining systems

The application of railroad rail piles are limited by the type of landslide, the distance the landslide scarp surfacing in the roadway is from the shoulder, and the depth to failure plane. Since railroad rail installation requires conventional drilling techniques, they are installed within embankment fills in areas accessible to drill rigs, typically near the roadway shoulder. The mass of soil retained is limited to the area between the railroad rail piles and the center lane of the roadway. The limiting distance of the roadway shoulder to the landslide scarp surfacing in the roadway was assumed to be about 20 feet. Railroad rail piles applied to larger slides that affect both driving lanes are usually ineffective. Finally, as dictated by design, the depth to failure plane is limited to 23 feet, although railroad rail piles have been successfully applied by KYTC to landslides with a

depth to failure plane near 30 feet. The limiting failure plane depth used in the landslide classification scheme for all cantilever piles methods was assumed to be 20 feet.

As previously mentioned, driven recycled plastic pins for landslide stabilization is still within the infant stages of research under the direction of Drs. John Bowders and Erik Loehr at the University of Missouri-Columbia. For the purpose of including recycled plastic pins as an applicable remedial method within the landslide classification scheme, the limiting depth to failure plane was assumed to be 20 feet, the same as railroad rail piles. Also, driven recycled plastic pins are best suited for minor earth slump landslides that occur at a sufficient distance above bedrock to provide adequate embedment of the plastic pins in competent soil.

Lime cement column installation cannot penetrate into rock, therefore it is only applicable to earth slump landslides. Also, equipment limitations used by Stabilator dictate that lime cement columns can only be installed to a depth of 82 feet. This limiting depth was rounded to 80 feet in the landslide classification scheme. No landslides are thought to have a depth to failure surface greater than 80 feet.

8.0 SUMMARY AND CONCLUSIONS

A substantial amount of the annual Indiana State road maintenance budget is spent to repair roadways damaged by landslides. The Indiana Department of Transportation typically repairs landslide using the excavation and backfill method, which is most cases proves successful, but typically costs more than $1,000 per foot of correction. In many cases more liberal landslide treatments may be applied that would arrest movement, provide a sufficient safety factor, and at a lower cost. Alternative landslide remedial methods are proposed, and a landslide classification scheme was developed which recommends suitable remedial solutions based upon the landslide classification. Eleven landslide types are recognized by the classification scheme, which is based upon four landslide attributes.

The following is a summary of findings/deliverables from this study:

1. Development of a landslide inventory/database that includes attribute information pertaining to landslide geometry and geologic environment for each of the 284 landslides documented.

2. Development of a geographic information system (GIS) database including geographic and geologic information relative to all landslide locations included in the inventory.

3. Correlation of landslide occurrence with geologic features using the constructed GIS database, concluding that landslide occurrence is a function of bedrock geology and topography.

4. Summary of potentially cost-effective alternative landslide remediation methods including conventional horizontal drainage, driven horizontal wick drains, driven recycled plastic pins, railroad rail piles, lime cement columns, biotechnical remediation, and gravity mass retaining systems.

5. Development of a landslide classification scheme, which recommends suitable remedial solutions based upon the landslide classification.

The inventory and GIS database were created so that landslide data could be more efficiently managed, and to enabled correlation of landslide occurrence with geologic features. Landslides are observed to occur in two primary clusters in the state, South Central Indiana, and Southeast Indiana. Landslide occurrence was shown to correlate with bedrock geology and topography. Because the landslide distribution within Indiana

is now well defined, the affect of standard design procedures and construction methods within areas prone to landslides may be more closely observed and refined within these areas. Refining standard construction techniques and procedures could dramatically reduce the number of landslides that affect constructed roadways, reducing road maintenance costs associated with landslides. Furthermore, cost savings may be realized from the proposed remedial methods: the proposed landslide remediation methods are often less expensive than the standard excavation and backfill method.

9.0 RECOMMENDATIONS

The following recommendations are provided based on the results of this study.

1. Employ and update the landslide database as part of the INDOT's standard operations. The constructed inventory may be revised as landslides occur and reoccur, and updated as landslide attribute information is better quantified. The constructed landslide inventory should prove a valuable tool that INDOT may build upon. A copy of the inventory is provided on disc in Appendix A in an Excel spreadsheet file.
2. Implement the geographic information system (GIS) software into the INDOT's standard operations. Most State transportation departments have implemented, or have taken steps required to implement GIS software into their operating procedure. The constructed database should prove to be a valuable tool that INDOT may build upon and utilize more extensively. GIS may also be used to map other geologic hazards common to Indiana. The ArcView (GIS software) project file containing landslide locations and associated geologic and geographic themes are provided on disc in Appendix A.
3. Implement the proposed alternative landslide remediation methods and, based on performance of these applications, refine the developed landslide classification scheme.
4. Modify standard construction specifications and design procedures within areas prone to landslides in order to reduce the number of future landslides affecting constructed roadways. Clearly, the existing standard specifications are not adequate in all geologic environments. The need to modify the existing specifications to be applicable within specific geologic environments is viewed as one of the most important findings from this study and could likely save the INDOT millions of dollars in road maintenance costs associated with landslides.
5. Develop a similar database of other geologic hazards that impact performance of our roadway system including, peat deposits, soft clays, abandoned underground mines, etc. The databases would provide excellent information for use in routing of new roadways and would provide guidance as to when existing standard specifications are inadequate for specific geologic environments.

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APPENDIX A

(Computer Files, Programs, and GIS Database Files on Separate Zip Disk)

APPENDIX B

LANDSLIDE INVENTORY
LEGEND OF ABBREVIATIONS AND DESCRIPTORS

Abbreviations

A# - *reference to designated area*
BL - *borelogs*
c- *cut slope*
C - *Crawfordsville*
CMP - *corrugated metal pipe*
cne- *correction not effective*
CPID - *concrete paved interceptor ditch*
csu- *correction status unknown*
D - *estimated depth to failure surface*
DO- *district office*
DOC- *Dan Chase, INDOT geologist*
e- *embankment*
E - *east*
e/c - *cut and embankment slope*
ERRF - *earliest reported record of failure*
es - *earth slump*
es-r - *earth slump on bedrock*
FI- *field investigation*
FS - *failure surface*
GW - *groundwater*
ID - *identification number*
L- *length of landslide*
og/pic- *log #/picture #*
n- *no*
N - *north*
nc- *not corrected*
nya - *not yet applicable*
nyc- *not yet corrected*
OB- *overburden depth*
pc- *partially corrected*
S - *south*
S - *Seymour*
s/r - *soil-rock*
SI - *slope inclinometer*
SV- *site visit*
V - *Vincennes*
W - *west*
W - *Widened*
W - *width of landslide*
y - *yes*

Vegetation Descriptors

t- *trace*
s- *sparse*
m- *moderate*
d- *dense*
vd- *very dense*
g- *grass (typically mowed)*
b- *low weeds &/or low brush*
st- *small trees*
t- *trees*

Bedrock Type

D - *Muscatatuck Group*
Dm - *New Albany Shale*
M1 - *Borden Group*
M2 - *Sanders Group*
M3 - *Blue River Group*
M4 - *West Baden Group*
M5 - *Stephensport Group*
M6 - *Buffalo Wallow Group*
O2 - *Kope Formation*
O3 - *Dillsboro Formation*
O4 - *Whitewater Formation*
P1 - *Raccoon Creek Group*
P2 - *Carbondale Group*
P3 - *Patoka & Shelburn Formation*
P4 - *Bond Formation*

Failure Position

U- *upper slope*
M- *middle slope*
L- *lower slope*
E- *entire slope*
(bench)- *Upper, lower etc. is relative to a bench in the slope and is not relative to the entire slope.*
1/3,1/3,3/4- *ratio of failed slope length to total slope length*

ID	File	Roadway	Location	County	photo log log/pic		date of ad uction	Earliest reported date of failure	Miscellaneous Comments
1	26/32	1	SR 1, just S of York Ridge Rd (Rd leading to Guilford), Area 1	Dearborn	10/17	cree	4 or 41	73	Per DO active slide, wedged, leveled and monitored by subdistrict. Per SV pavement through slide area very uneven.
2	26/32	1	SR 1, Junct. Mt. Pleasant Rd, Area 2	Dearborn	10/16	poss bedr	5 or 41	76	Per DO active slide, wedged, leveled and monitored by subdistrict. Per SV pavement through slide area very uneven. May be part of a much larger slide that includes entire hillside.
3	26/32	1	SR 1, 0.15 mi S of Pribble Rd, Area 3	Dearborn	10/14	toe c	6 or 41	69	Per DO active slide, wedged, leveled and monitored by subdistrict. Per SV pavement through slide area very uneven.
4	26/32	1	SR 1, 0.46 mi S of Pribble Rd, Area 4	Dearborn	10/15	leak	7 or 41	73	Per DO active slide, wedged, leveled and monitored by subdistrict. Per SV pavement through slide area very uneven.
5	26/32	1	SR 1, 0.53 mi S of Pribble Rd, Area 5	Dearborn	10/15	slop GW	8 or 41	76	Per DO active slide, wedged, leveled and monitored by subdistrict. Per SV pavement through slide area very uneven.
6	26/32	1	SR 1, 1.0 mi N Guilford Rd	Dearborn	10/18,19	cree	2 or 41	87	Per DO active slide, wedged, leveled and monitored by subdistrict.
7	26/32	1	SR 1, 2.2 mi N Guilford Rd	Dearborn		engi	3 or 41	87	Per DO active slide, wedged, leveled and monitored by subdistrict
8	new	1	SR 1, 0.6 mi N SR 46, 'St. Leon slide', Area 1	Dearborn	9/24	satu		9/97	
9	new	1	SR 1, 0.6 mi N SR 46, 'St. Leon slide', Area 2	Dearborn	9/24	satu		9/97	
10	37/39/43	1	Old SR 1, 0.6 mi S US 52	Franklin	9/14-16	cree		Jun-80	Per DO maint forces ditched, installed drainage cross-str., rip rap banks-areas basically stable
11	37/39/43	1	Old SR 1, 1.0 mi S US 52	Franklin	9/13	cree		Jun-80	Per DO maint forces ditched, installed drainage cross-str., rip rap banks-areas basically stable.
12	112	37	SR 37, 0.6 mi N SR 64	Crawford		cree	, W 64	Oct-91	Per DO under construction Dec '97.
13	18	37	SR 37, 0.7 mi N of SR 48	Monroe	8/10	poss struc	72, 91	Jun-94	Per DO active slide.
14	10	37	SR 37, 0.8 mi S. Patoka River	Orange	4/17	slop bloc	81	86	Slow movement over years; more movement 8/96. Per DO moves 2-3"/yr., high priority.
15	89/208	37	SR 37, 0.8 mi S of US 150	Orange	5/1	GW	57	79	Previous recommendation of LS remediation in 1979 Per DO repaired 1993.
16	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 1	Crawford	1/8-10	cree	25	Jun-80	Per DO cracks in rd in repair area and N of repair; cracks in road
17	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 2	Crawford		cree	25	Jun-80	Per DO cracks in rd in repair area and N of repair; cracks in road
18	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 3	Crawford		cree	25	Jun-80	Per DO cracks in rd in repair area and N of repair; cracks in road
19	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 4	Crawford		cree	25	Jun-80	Per DO cracks in rd in repair area and N of repair, cracks in road
20	31/90	37	SR 37, 1 0-1.3 mi N I-64, Area 5	Crawford		cree	25	Jun-80	Per DO cracks in rd in repair area and N of repair; cracks in road
21	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 6	Crawford		cree	25	Jun-80	Per DO cracks in rd in repair area and N of repair, cracks in road
22	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 7	Crawford		cree	25	Jun-80	Per DO cracks in rd in repair area and N of repair, cracks in road
23	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 1a	Lawrence	6/5	addi	69, 73	Apr-84	
24	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 1b	Lawrence	6/4	addi	59, 73	Apr-84	
25	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 2a	Lawrence	6/3	cree @ to slop drain	59, 73	Apr-84	
26	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 2b	Lawrence	6/3	cree @ to slop drain	69, 73	Apr-84	
27	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 2c	Lawrence	6/3	cree @ to slop drain	69, 73	Apr-84	
28	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 3a	Lawrence	6/2	cree outle shou	69, 73	Apr-84	
29	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 3b	Lawrence	6/2	cree outle shou	69, 73	Apr-84	
30	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 3c	Lawrence	6/2	cree outle slop drain	69, 73	Apr-84	
31	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 4a	Lawrence	6/2	cree outle shou	69, 73	Apr-84	
32	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 4b	Lawrence	6/2	cree outle shou	69, 73	Apr-84	
33	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 4c	Lawrence	6/2	cree outle shou	69, 73	Apr-84	
34	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 4d	Lawrence	6/2	cree outle shou	69, 73	Apr-84	
35	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 4e	Lawrence	6/2	cree outle shou	69, 73	Apr-84	
36	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 5	Lawrence	6/1	cree outle shou	69, 73	Apr-84	
37	7	37	SR 37, 2.1-2.4 mi N of SR 54, N area	Lawrence	4/2-4		69	77	area of old and frequent slides. Per DO moves 4 times/yr; High priority. Per site visit 5/20/98 2 active areas dumping soil on shoulder below by

LANDSLIDE INVENTORY

														GEOMETRIC INFORMATION								DATA AVAILABLE					
ID	File	Roadway	Location	County	photo log log/pic	Probable Cause	Remedial Method	Vegetation	Correction status	Landslide type	Slope type	Bedrock type	Failure position	Slope (°)	W ft	L ft	plan area ft²	D ft	OB (range) ft	OB (avg) ft	volume yds³	Field sketch	Borelogs	Slope inc.	Initial date of road construction	Earliest reported date of failure	Miscellaneous Comments
1	26/32	1	SR 1, just S of York Ridge Rd (Rd leading to Guilford), Area 1	Dearborn	10/17	creek erosion of toe, sloping bedrock	Rip rap or rock backfill still failing, report recomm. rock buttress or isolated drilled piers	dt outside r/r	cne	es-r	e	o2	E		260	60	12,252	25	30-33	32	7,563	y	y	n	34 or 41	73	Per DO active slide, wedged, leveled and monitored by subdistrict. Per SV pavement through slide area very uneven
2	26/32	1	SR 1, Junct. Mt Pleasant Rd, Area 2	Dearborn	10/16	possible water line leak, sloping bedrock	rock buttress, 'b' borrow key, rock key or drilled piers, rock key for hill	dg, st	nc	es-r	e	o2	L1/?	10-22	600	480	226,195	15	18-22	20	83,776	y	y	y	35 or 41	76	Per DO active slide, wedged, leveled and monitored by subdistrict. Per SV pavement through slide area very uneven. May be part of a much larger slide that includes entire hillside.
3	26/32	1	SR 1, 0.15 mi S of Pribble Rd, Area 3	Dearborn	10/14	toe ditched by railroad, sloping bedrock	rock buttress, rock key 2:1 or comp fill 2.5:1	dt	nc	es-r	e	o2	E	16	400	180	56,549	30	10-20	15	41,886	y	y	y	36 or 41	69	Per DO active slide, wedged, leveled and monitored by subdistrict. Per SV pavement through slide area very uneven
4	26/32	1	SR 1, 0.46 mi S of Pribble Rd, Area 4	Dearborn	10/15	leaky box culvert crossing road	rock key 2:1, 'b' borrow 2:1, comp backfill 3:1, or isolated drilled piers	dt, s-mt	nc	es-r	e	o2	E	18	210	100	16,493	23	19-32	26	9,367	y	y		37 or 41	73	Per DO active slide, wedged, leveled and monitored by subdistrict. Per SV pavement through slide area very uneven.
5	26/32	1	SR 1, 0.53 mi S of Pribble Rd, Area 5	Dearborn	10/15	sloping bedrock, inadequate benching, GW weakened shale	rock buttress, rock key, or isolated drilled piers	dt, s-mt	nc	es-r	e	o2	E	21	150	100	11,781	16	20-25	23	4,654	y	y		38 or 41	76	Per DO active slide, wedged, leveled and monitored by subdistrict. Per SV pavement through slide area very uneven
6	26/32	1	SR 1, 1.0 mi N Guilford Rd	Dearborn	10/18,19	creek erosion of toe, sloping bedrock	rip rap or rock backfill, report recommends rock backfill	d-vdt	cne	es-r	e	o2	E	30	180	35	4,948		3-20	12	1,405	y	y	n	32 or 41	87	Per DO active slide, wedged, leveled and monitored by subdistrict
7	26/32	1	SR 1, 2.2 mi N Guilford Rd	Dearborn		engineering of fill			nc		e	o2							<25	25		y	y	n	33 or 41	87	Per DO active slide, wedged, leveled and monitored by subdistrict
8	new	1	SR 1, 0.6 mi N SR 46, 'St. Leon slide', Area 1	Dearborn	9/24	saturation of slope from CMP	rock backfill	dg, mb	nc	es	e	o3	L3/4	27	172	67	9,051	12	20-35	28	2,682	y	y	y		9/97	
9	new	1	SR 1, 0.6 mi N SR 46, 'St. Leon slide', Area 2	Dearborn	9/24	saturation of slope from CMP	rock backfill	dg, mb	nc	es	e	o4	L3/4	29	106	75	6,244		20-30	25		y	y	y		9/97	
10	37/39/43	1	Old SR 1, 0.6 mi S US 52	Franklin	9/14-16	creek erosion of toe	relocated road	dt	c	es-r	e	o2	E	36	435	58	19,816		8-15	12	5,627	y	y	n		Jun-80	Per DO maint forces ditched, installed drainage cross-str., rip rap banks-areas basically stable.
11	37/39/43	1	Old SR 1, 1.0 mi S US 52	Franklin	9/13	creek erosion of toe	relocated road	d-vdt	c	es-r	e	o2	E	30	500	70	27,469	10	10-18	14	6,787	y	y	n		Jun-80	Per DO maint forces ditched, installed drainage cross-str., rip rap banks-areas basically stable.
12	112	37	SR 37, 0.6 mi N SR 64	Crawford		creek @ toe	road realignment		c		e/c	m4		45	450	60	21,206					n	n	n	25, W 64	Oct-91	Per DO under construction Dec '97.
13	18	37	SR 37, 0.7 mi N of SR 48	Monroe	8/10	possibly due to blocked drainage structure behind bridge bent	rock backfill	sst, sb w/in failure, dg outside of failure	nc	es	e	m3	E	18	75	80	4,712		<20	20		y	n	n	72, 91	Jun-94	Per DO active slide.
14	10	37	SR 37, 0.6 mi S. Patoka River	Orange	4/17	sloping bedrock, GW @ s/r interface, blocked culvert, creek eroding toe	rock backfill	dt; scarp in rd; dt above scarp	nc	es-r	e	m4	E	36	270	150	31,809	17	0-16	8	13,352	y	y	n	81	86	Slow movement over years; more movement 8/96 Per DO moves 2-3"/yr., high priority.
15	89/208	37	SR 37, 0.8 mi S of US 150	Orange	5/1	GW @ s/r interface	rock backfill	vdg	c	es-r	e	m3	E	37	195	40	6,126		10-24	17	2,571	y	y	n	57	79	Previous recommendation of LS remediation in 1979 Per DO repaired 1993.
16	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 1	Crawford	1/8-10	creek @ toe		m-dt	nc	es-r	e	m4	E	36	260	200	40,841	28	8-20	14	28,236	y	y	y	25	Jun-80	Per DO cracks in rd in repair area and N of repair; cracks in road
17	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 2	Crawford		creek @ toe	rock backfill and bin wall	m-dt beyond toe of r/r	c	es-r	e	m3	U3/4	25	135	90	9,543	15	8-20	14	3,534	y	y	y	25	Jun-80	Per DO cracks in rd in repair area and N of repair; cracks in road
18	31/90	37	SR 37, 1.0-1.3 mi N I-64 Area 3	Crawford		creek @ toe	rock backfill and bin wall	m-dt beyond toe of r/r	c	es-r	e	m3	E	25	95	100	7,461	10	8-20	14	1,842	y	y	y	25	Jun-80	Per DO cracks in rd in repair area and N of repair; cracks in road
19	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 4	Crawford		creek @ toe	rock backfill and bin wall	m-dt beyond toe of r/r	c	es-r	e	m3	E	25	50	100	3,927	10	8-20	14	970	y	y	y	25	Jun-80	Per DO cracks in rd in repair area and N of repair, cracks in road
20	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 5	Crawford		creek @ toe	rock backfill and bin wall	m-dt beyond toe of r/r	c	es-r	e	m3	E	25	230	160	28,903	10	8-20	14	7,136	y	y	y	25	Jun-80	Per DO cracks in rd in repair area and N of repair; cracks in road
21	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 6	Crawford		creek @ toe	rock backfill and bin wall	m-dt beyond toe of r/r	csu	es-r	e	m3	U1/2		120	90	8,482	10	8-20	14	2,094	y	y	y	25	Jun-80	Per DO cracks in rd in repair area and N of repair, cracks in road
22	31/90	37	SR 37, 1.0-1.3 mi N I-64, Area 7	Crawford		creek @ toe			nc	es-r	e	m3	U1/2		300	120	28,274	10	8-20	14	6,981	y	y	y	25	Jun-80	Per DO cracks in rd in repair area and N of repair; cracks in road
23	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 1a	Lawrence	6/5	addition of fill material	rock backfill	b, st	c		e	m2	L3/4	23	213	62	10,372		5-30	18		y	n	n	69, 73	Apr-84	
24	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 1b	Lawrence	6/4	addition of fill material	rock backfill	b, st	c		e	m2	E	30	96	69	5,202		5-30	18		y	n	n	69, 73	Apr-84	
25	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 2a	Lawrence	6/3	creek @ toe, 4" abandoned water line @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	E	30	116	32	2,915		5-30	18		y	n	n	69, 73	Apr-84	
26	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 2b	Lawrence	6/3	creek @ toe, 4" abandoned water line @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	U1/2	30	47	20	738		5-30	18		y	n	n	69, 73	Apr-84	
27	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 2c	Lawrence	6/3	creek @ toe, 4" abandoned water line @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	U3/4	30	96	27	2,036		5-30	18		y	n	n	69, 73	Apr-84	
28	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 3a	Lawrence	6/2	creek @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	E	22	95	35	2,611		5-30	18		y	n	n	69, 73	Apr-84	
29	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 3b	Lawrence	6/2	creek @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	E	22	200	60	9,425	7	5-30	18	1,629	y	n	n	69, 73	Apr-84	
30	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 3c	Lawrence	6/2	creek @ toe, failure @ shoulder drain outlet and CMP outlet on edge of slide, slope saturated by clogged median drain.	rip rap	b, st	c		e	m2	E	22	123	43	4,154		5-30	18		y	n	n	69, 73	Apr-84	
31	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 4a	Lawrence	6/2	creek @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	M1/2	22	50	27	1,060		5-30	18		y	n	n	69, 73	Apr-84	
32	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 4b	Lawrence	6/2	creek @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	L3/4	22	90	56	3,958	7	5-30	18	684	y	n	n	69, 73	Apr-84	
33	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 4c	Lawrence	6/2	creek @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	L1/2	22	45	46	1,626		5-30	18		y	n	n	69, 73	Apr-84	
34	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 4d	Lawrence	6/2	creek @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	E	22	190	95	14,176		5-30	18		y	n	n	69, 73	Apr-84	
35	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 4e	Lawrence	6/2	creek @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	U1/4	22	33	26	674		5-30	18		y	n	n	69, 73	Apr-84	
36	48/49/92	37	SR 37, 1.0 mi S SR 54 to Patton Hill Rd, Area 5	Lawrence	6/1	creek @ toe, failure @ shoulder drain outlet, slope saturated by clogged shoulder drain	rip rap	b, st	c		e	m2	L3/4	29	113	80	7,100		5-30	18		y	n	n	69, 73	Apr-84	
37	7	37	SR 37, 2.1-2.4 mi N of SR 54, N area	Lawrence	4/2-4			mg-b, st; dt @ top beyond scarp	nc	es-r	c	m3	E	27	76	77	4,596		35	35	3,972	n	n	n	69	77	area of old and frequent slides. Per DO moves 4 times/yr; High priority. Per site visit 5/20/98 2 active areas dumping soil on shoulder below by

ID	File	Roadway	Location	County	photo log log/pic		d date of road truction	Earliest reported date of failure	Miscellaneous Comments
									erosion and movement? Many scarps visible. Apparent dip of bedrock 2°.
38	7	37	SR 37, 2.1-2.4 mi N of SR 54, S area	Lawrence	4/1,5,6		69	77	area of old and frequent slides. Per DO moves 4 times/yr; High priority. Per site visit 5/20/98 2 active areas dumping soil on shoulder below by erosion and movement? Many scarps visible. Apparent dip of bedrock 2°.
39	111/210	37	SR 37, 2.35 mi E of Tell City	Perry	2/8		73	May-93	Per DO correction by INDOT not effective; not affecting road or ditch, not a priority.
40	110/209	37	SR 37, 6.1 mi N SR 70, Area 1	Perry	5/6	too	73	Nov-89	
41	110/209	37	SR 37, 6.1 mi N SR 70, Area 2	Perry	5/6	too	73	Nov-89	
42	110/209	37	SR 37, 6.7 mi N SR 70	Perry	5/7	too	73	83	Per DO repaired 1997. May have been due to poor compaction during construction of road in 78-79. Per SV no apparent sign of failure.
43	110/209	37	SR 37, 7.1 mi N SR 70	Perry	1/20,21	too	73	Nov-89	Per DO not priority
44	110/209	37	SR 37, 9.3 mi N SR 70	Perry	5/8	too	73	Nov-89	
45	25	37	SR 37 @ SR 48 interchange, Area 1 across from A-4	Monroe	8/11		91	Jun-94	
46	25	37	SR 37 @ SR 48 interchange, Area 2 across from A-4	Monroe	8/11	are	91	Jun-94	
47	25	37	SR 37 @ SR 48 interchange, Area 3, across from A-4	Monroe	8/11	are	91	Jun-94	
48	25	37	SR 37 @ SR 48 interchange, Area 4, across from A-1, A-2, A-3	Monroe	8/12		91	Jun-94	
49	207	37	Old SR 37 over Seaboard RR, Area 1 across from A-3	Monroe	8/14	eng	72	Feb-88	Failures in newly compacted fill. Per DO basically stable.
50	207	37	Old SR 37 over Seaboard RR, Area 2 across from A-3	Monroe	8/14	eng	72	Feb-88	Failures in newly compacted fill. Per DO basically stable.
51	207	37	Old SR 37 over Seaboard RR, Area 3 across from A-1, A-2	Monroe	8/13	eng	72	Feb-88	Failures in newly compacted fill. Per DO basically stable.
52	2	37	SR 46/SR 37 junct, Area 1	Monroe	8/9	fail em	72	78	
53	2	37	SR 46/SR 37 junct, Area 2	Monroe	8/8	fail	72	78	1978 original failure, recurrent in Aug '96 Part of emb over old quarry. In 78 remediate by building slope to 3:1 Per DOC and DO Intersection modification will fix slides.
54	30	37	Old SR 37,1.0 mi S of Gratsburg	Crawford	5/5	cre dra	30, 35, 56, 82	83	
55	3	41	US 41, 4 6 mi N of SR 64 Area 1	Gibson	3/21,22	fail	57	87	Good pictures in Dan's file taken in winter
56	3	41	US 41, 4 6 mi N of SR 64, Area 2	Gibson		fail	57	87	Good pictures in Dan's file taken in winter
57	14	41	US 41, 0.5 mi N of SR 47	Parke	7/10-12		25, R93	Jul-79	Per DO added stone to slope and asphalt to road, seems not to be stabilized. Per SV, AP patches and cracks, fresh scarp or erosion to S of main slide.
58	8	46	SR 46, 2.8 mi W of US 52	Dearbom	9/23	cre	37	70	Per DOC, may need urgent attention in '98 and pre 1970 binwall correction failed, scarp in road caused frequent hazard Per DO active slide, wedged, leveled and monitored by subdistrict
59	9/109	48	SR 48, SR 148-US 50, Area 1	Dearbom			55	88	Geotech report completed in 1988 for proposed realignment. Per DO being monitored.
60	9/109	48	SR 48, SR 148-US 50, Area 2	Dearbom			55	88	Geotech report completed in 1988 for proposed realignment Per DO being monitored.
61	9/109	48	SR 48, SR 148-US 50, Area 3	Dearbom	11/3		55	88	Geotech report completed in 1988 for proposed realignment. Per DO being monitored.
62	9/109	48	SR 48, 0.5 mi W of US 50, Area 4	Dearbom	11/2	slo @	55	Feb-83	Geotech report completed in 1988 for proposed realignment Per DO fixing under contract in 1998
63	24	48	US 48, Industrial drive in Lawrenceburg, Area 1	Dearbom	10/20			92	1992 new road construction. Per DOC and DO bypass project will fix problem. Per DO being monitored.
64	24	48	US 48, Industrial drive in Lawrenceburg, Area 2	Dearbom	10/20			92	1992 new road construction. Per DOC and DO bypass project will fix problem. Per DO being monitored
65	24	48	US 48, Industrial drive in Lawrenceburg, Area 3	Dearbom	10/21			92	1992 new road construction. Per DOC and DO bypass project will fix problem. Per DO being monitored.
66	24	48	US 48, Industrial drive in Lawrenceburg, Area 4	Dearbom	10/24			92	1992 new road construction. Per DOC and DO bypass project will fix problem. Per DO being monitored.
67	24	48	US 48, Industrial drive in Lawrenceburg, Area 5	Dearbom	10/22,23			92	1992 new road construction. Per DOC and DO bypass project will fix problem. Per DO being monitored.
68	24	48	US 48, Industrial drive in Lawrenceburg, Area 6	Dearbom				92	1992 new road construction. Per DOC and DO bypass project will fix problem. Per DO being monitored.
69	24	48	US 48, Industrial drive in Lawrenceburg, Area 7	Dearbom	11/1			92	1992 new road construction. Per DOC and DO bypass project will fix problem. Per DO being monitored
70	88	50	US 50, 0.05 mi E SR 450	Martin	4/13, 5/22	eng slo slid	30, 91	Apr-84	Per DO, slopes too steep in fill section, moves annually, INDOT placed some rip rap;Low priority. Per SV no apparent LS features.
71	34	50	US 50, 1.6 mi W of SR 56	Dearbom	11/10	clo CM eng	52	Aug-84	Slope failure during construction of US 50. Per DO repairs by maintenance forces-monitored regularly.
72	87	50	US 50, 1.9 mi E US 421	Ripley	12/3	cre bed	90	Dec-83	Per DO bin wall constructed by maint. contract-wall needs extending.
73	42.1/93	52	US 52, 1.85 mi W SR 1 (NW junction), Area 1	Franklin	9/12		29	May-93	Per DO active slides. Old canal at toe.
74	42.1/93	52	US 52, 1.51 mi W SR 1 (NW junction), Area 2	Franklin	9/9-11	dra	29	May-93	Per DO active slides. Old canal at toe. Lower slope of A-3
75	42.1/93	52	US 52, 1.49 mi W SR 1 (NW junction), Area 3	Franklin	9/9-11		29	May-93	Per DO active slides. Old canal at toe. Upper cutslope of A-2
76	42.1/93	52	US 52, 1.25 mi W SR 1 (NW junction), Area 4	Franklin	9/8		29	May-93	Per DO active slides. Old canal at toe.
77	42.1/93	52	US 52, 1.14 mi W SR 1 (NW junction), Area 5	Franklin			29	May-93	Per DO active slides. Old canal at toe.

LANDSLIDE INVENTORY

ID	File	Roadway	Location	County	photo log log/pic	Probable Cause	Remedial Method	Vegetation	Correction status	Landslide type	Slope type	Bedrock type	Failure position	GEOMETRIC INFORMATION Slope (°)	W ft	L ft	plan area ft²	D ft	OB (range) ft	OB (avg) ft	volume yds³	DATA AVAILABLE Field sketch	Borelogs	Slope inc.	Initial date of road construction	Earliest reported date of failure	Miscellaneous Comments
																											erosion and movement? Many scarps visible. Apparent dip of bedrock 2°
38	7	37	SR 37, 2.1-2 4 mi N of SR 54, S area	Lawrence	4/1,5,6			mg-b,dt @ top beyond scarp	nc	es-r	c	m3	E	27	108	51	4,326		23	23	2,457	n	n	n	69	77	area of old and frequent slides. Per DO moves 4 times/yr, High priority Per site visit 5/20/96 2 active areas dumping soil on shoulder below by erosion and movement? Many scarps visible. Apparent dip of bedrock 2°.
39	111/210	37	SR 37, 2 35 mi E of Tell City	Perry	2/8		rip rap	m-dg	cne		c	p1	E	18	140	110	12,095					y	n	n	73	May-93	Per DO correction by INDOT not effective, not affecting road or ditch, not a priority
40	110/209	37	SR 37 6 1 mi N SR 70, Area 1	Perry	5/6	too steep		sst-db & dg	nc		c	p1	L3/4	25	145	80	9,111	10	<10	10	2,250	n	n	n	73	Nov-89	
41	110/209	37	SR 37, 6 1 mi N SR 70, Area 2	Perry	5/6	too steep		sst-db & dg	nc		c	p1	L1/2	25	60	60	2,827		<10	10		n	n	n	73	Nov-89	
42	110/209	37	SR 37, 6 7 mi N SR 70	Perry	5/7	too steep	regraded?	dg, st	c		e	p1	E	27	650	180	91,892	20	10-20	15	45,379	n	y	n	73	83	Per DO repaired 1997 May have been due to poor compaction during construction of road in 76-79 Per SV no apparent sign of failure
43	110/209	37	SR 37, 7 1 mi N SR 70	Perry	1/20,21	too steep		dg, st	nc		c	p1	E	27	140	40	4,398		<10	10		n	y	n	73	Nov-69	Per DO not priority
44	110/209	37	SR 37, 9 3 mi N SR 70	Perry	5/8	too steep	rock backfill	st, dg	c		c	p1	E	23	120	50	4,712		<10	10		n	y	n	73	Nov-69	
45	25	37	SR 37 @ SR 48 interchange, Area 1 across from A-4	Monroe	8/11		rock backfill	vdg-mb	nc	es	e	m3	L1/2	26	30	30	707		10-25	18		y	y	n	91	Jun-94	
46	25	37	SR 37 @ SR 48 interchange, Area 2 across from A-4	Monroe	8/11	area is adjacent to CMP outlet	rock backfill	vdg-mb	nc	es	e	m3	M1/2	26	50	25	982		10-25	18		y	y	n	91	Jun-94	
47	25	37	SR 37 @ SR 48 interchange, Area 3, across from A-4	Monroe	8/11	area is adjacent to CMP outlet	rock backfill	vdg-mb	nc	es	e	m3	M1/2	26	50	25	982		10-25	18		y	y	n	91	Jun-94	
48	25	37	SR 37 @ SR 48 interchange, Area 4, across from A-1, A-2, A-3	Monroe	8/12		rock backfill to match existing slope or to extend to 3 1	vdg, mst, mt	nc	es	e	m3	L3/4	27	90	40	2,827		10-25	18		y	y	n	91	Jun-94	
49	207	37	Old SR 37 over Seaboard RR, Area 1 across from A-3	Monroe	8/14	engineering of fill	soil backfill	vdg, sst	nc	es	e	m1	U3/4	28	60	50	2,356	25			1,454	y	y	n	72	Feb-88	Failures in newly compacted fill Per DO basically stable
50	207	37	Old SR 37 over Seaboard RR, Area 2 across from A-3	Monroe	8/14	engineering of fill	soil backfill	vdg, sst	nc	es	e	m1	L1/2	28	55	40	1,728	25			1,067	y	y	n	72	Feb-88	Failures in newly compacted fill. Per DO basically stable
51	207	37	Old SR 37 over Seaboard RR, Area 3 across from A-1, A-2	Monroe	8/13	engineering of fill	soil backfill	vdg mb, mst	nc	es	e	m1	U1/2	28	97	35	2,666	15			986	y	y	n	72	Feb-88	Failures in newly compacted fill Per DO basically stable
52	2	37	SR 46/SR 37 junct, Area 1	Monroe	8/9	failure occurs adjacent to culvert inlet, emb built over former quarry	intersection modification will fix failure	dg, cattails in mid slope	nc	es	e	m3	L3/4	22	98	56	4,309	10	0-70	35	1,064	y	y	n	72	78	
53	2	37	SR 46/SR 37 junct, Area 2	Monroe	8/8	failure occurs adjacent to culvert outlet	intersection modification will fix failure	s-mt, dg	nc	es	e	m3	E	20	59	98	4,563	15	0-70	35	1,690	y	y	n	72	78	1978 original failure, recurrent in Aug '96 Part of emb over old quarry. In 78 remediate by building slope to 3 1 Per DOC and DO Intersection modification will fix slides
54	30	37	Old SR 37,1 0 mi S of Gratsburg	Crawford	5/5	creek @ toe, inadequate benching & drainage	rock backfill proposed, but road relocated	vdt	nc	es-r	e	m3	E	22	250	260	51,051	16	3-16	10	20,168	y	y	n	25, 30, 35, 56 82	83	
55	3	41	US 41, 4 6 mi N of SR 64 Area 1	Gibson	3/21,22	failed CPID	rock backfill	dt outside LS, dg w/in LS	nc	es	c	p3	E(bench)	28	165	50	6 460	14	>50	50	2,240	y	n	n	57	87	Good pictures in Dan's file taken in winter
56	3	41	US 41, 4 6 mi N of SR 64, Area 2	Gibson		failed CPID	rock backfill	dt outside LS, dg w/in LS	nc	es	c	p3	E(bench)	28	60	45	2,121		>50	50		y	n	n	57	87	Good pictures in Dan's file taken in winter
57	14	41	US 41, 0 5 mi N of SR 47	Parke	7/10-12		rip rap	m-dt	cne	es-r	e	p1	E	34	300	105	24,740		20	20	12,217	y	y	n	25, R93	Jul-79	Per DO added stone to slope and asphalt to road, seems not to be stabilized Per SV, AP patches and cracks, fresh scarp or erosion to S of main slide.
58	8	46	SR 46, 2 8 mi W of US 52	Dearborn	9/23	creek erosion of toe	metal bin retaining wall is still failing	dg outside r/r; dt @ toe	cne	es-r	e	o3	E	16	525	95	39,172	24	25	25	23,213	y	n	n	37	70	Per DDC, may need urgent attention in '98 and pre 1970 binwall correction failed, scarp in road caused frequent hazard Per DO active slide, wedged, leveled and monitored by subdistrict
59	9/109	48	SR 48, SR 148-US 50, Area 1	Dearborn			realignment		nc		e	o2										n	n	n	55	88	Geotech report completed in 1988 for proposed realignment Per DO being monitored.
60	9/109	48	SR 48, SR 148-US 50, Area 2	Dearborn			realignment		nc		e	o2										n	n	n	55	88	Geotech report completed in 1988 for proposed realignment Per DO being monitored
61	9/109	48	SR 48, SR 148-US 50, Area 3	Dearborn	11/3		realignment	vdt	nc		e	o2										n	n	n	55	88	Geotech report completed in 1988 for proposed realignment Per DO being monitored
62	9/109	48	SR 48, 0.5 mi W of US 50, Area 4	Dearborn	11/2	sloping bedrock, engineering of fill, GW @ soil/rock interface	rock and soil backfill	vdt	nyc	es-r	e	o2	U1/?	16	275	70	15,119	10	3-12	8	3,733	y	y	n	55	Feb-83	Geotech report completed in 1988 for proposed realignment. Per DD fixing under contract in 1998
63	24	48	US 48, Industrial drive in Lawrenceburg, Area 1	Dearborn	10/20			dg-db	nc	es-r	c	o2	M1/?	23	144	56	6,324	15	15	15	2,342	y	n	n		92	1992 new road construction Per DOC and DO bypass project will fix problem. Per DO being monitored
64	24	48	US 48, Industrial drive in Lawrenceburg, Area 2	Dearborn	10/20			dg-db	nc		c	o2	U1/4(bench)	23	295	46	10,642	15	15	15	3,941	y	n			92	1992 new road construction. Per DOC and DO bypass project will fix problem Per DO being monitored
65	24	48	US 48, Industrial drive in Lawrenceburg, Area 3	Dearborn	10/21			d-vdg, cattails @ toe of upper bench	nc		c	o2	M1/3	25	148	46	5,321	15	15	15	1,971	y	n			92	1992 new road construction Per DOC and DO bypass project will fix problem Per DO being monitored.
66	24	48	US 48, Industrial drive in Lawrenceburg, Area 4	Dearborn	10/24			vdg	nc		c	o2	M1/3	18	164	56	7,187	15	15	15	2,662	y	n			92	1992 new road construction. Per DOC and DO bypass project will fix problem. Per DO being monitored
67	24	48	US 48, Industrial drive in Lawrenceburg, Area 5	Dearborn	10/22,23			vdg	nc		c	o2	M1/4	22	49	45	1,747	15	15	15	647	y	n	n		92	1992 new road construction Per DOC and DO bypass project will fix problem. Per DO being monitored
68	24	48	US 48, Industrial drive in Lawrenceburg, Area 6	Dearborn					nc		c	o2	U1/4(bench)	25	49	20	761	15	15	15	282	y	n	n		92	1992 new road construction. Per DOC and DO bypass project will fix problem. Per DO being monitored.
69	24	48	US 48, Industrial drive in Lawrenceburg, Area 7	Dearborn	11/1			vdt	nc		c	o2	E(bench)	23	279	157	34,466	15	15	15	12,765	y	n	n		92	1992 new road construction Per DOC and DO bypass project will fix problem Per DO being monitored
70	88	50	US 50, 0 05 mi E SR 450	Martin	4/13, 5/22	engineering of fill, poor drainage, sloping bedrock, cmp outlet in center of slide1	rock backfill	db-t outside r/r	c	es-r	e	p1	U3/4	35	125	50	4,909	13	2-15	9	1,576	y	y	n	30, 91	Apr-84	Per DO, slopes too steep in fill section, moves annually, INDOT placed some rip rap;Low priority. Per SV no apparent LS features.
71	34	50	US 50, 1.6 mi W of SR 56	Dearborn	11/10	clogging of CMP, creek out of line w/ CMP caused scour, sloping bedrock, engineering of fill	rock backfill	dg, s-mt outside r/r	c	es-r	e	o2	E	23	395	130	40,330	22	15-30	23	21,908	y	y	y	52	Aug-84	Slope failure during construction of US 50 Per DO repairs by maintenance forces-monitored regularly
72	87	50	US 50, 1.9 mi E US 421	Ripley	12/3	creek erosion of toe, too steep, sloping bedrock, box culvert at flank of slide	retaining wall needs expanding, report recommended rock backfill	dg flanking wall; r/r above wall	cne	es-r	e	o3	E		130	27	2,757		<25	25	1,702	y	n	n	90	Dec-83	Per DO bin wall constructed by maint. contract-wall needs extending
73	42 1/93	52	US 52, 1 85 mi W SR 1 (NW junction), Area 1	Franklin	9/12			dt	nc		e	o3	U1/4	30	60	55	2,592					y	n	n	29	May-93	Per DO active slides Old canal at toe
74	42 1/93	52	US 52, 1 51 mi W SR 1 (NW junction), Area 2	Franklin	9/9-11	drainage outlet onto slope within failure	rip rap or rock backfill still failing	mg-st w/in r/r; dt @ toe	cne		e	o3	E	21	470	190	70,136	18			31,172	y	n	n	29	May-93	Per DO active slides. Old canal at toe Lower slope of A-3
75	42.1/93	52	US 52, 1 49 mi W SR 1 (NW junction), Area 3	Franklin	9/9-11			d-vdt	nc		c	o3	L1/?	26	730	150	66,001	14			29,729	y	n	n	29	May-93	Per DO active slides. Old canal at toe Upper cutslope of A-2
76	42 1/93	52	US 52, 1 25 mi W SR 1 (NW junction), Area 4	Franklin	9/8		rock backfill	d-vdt	nc		c	o3	L1/?	35	90	45	3,181					y	n	n	29	May-93	Per DO active slides Old canal at toe.
77	42 1/93	52	US 52, 1.14 mi W SR 1 (NW junction), Area 5	Franklin					nc		e	o3	E		100	135	10,603					y	n	n	29	May-93	Per DO active slides. Old canal at toe.

ID	File	Roadway	Location	County	photo log log/pic		date of ed uction	Earliest reported date of failure	Miscellaneous Comments
78	42.1/93	52	US 52, 1.09 mi W SR 1 (NW junction), Area 6	Franklin	9/6		29	May-93	Per DO active slides. Old canal at toe.
79	42.1/93	52	US 52, 0.98 mi W SR 1 (NW junction), Area 7	Franklin	9/7		29	May-93	Per DO active slides. Old canal at toe.
80	42.1/93	52	US 52, 0.73 mi W SR 1 (NW junction), Area 8	Franklin	9/3,4	drair engi adve	29	May-93	Per DO active slides. Old canal at toe.
81	42.1/93	52	US 52, 0.67 mi W SR 1 (NW junction), Area 9	Franklin	9/5	engi adve	29	Oct-85	Per DO active slides. Old canal at toe. Thick sandy gravel layers in subsurface.
82	42.1/93	52	US 52, 0.60 mi W SR 1 (NW junction), Area 10	Franklin		engi	29	May-93	Per DO active slides. Old canal at toe. Thick sandy gravel layers in subsurface. Failure looks regressive.
83	42.1/93	52	US 52, 0.51 mi W SR 1 (NW junction), Area 11	Franklin	9/2		29	May-93	Per DO active slides. Old canal at toe.
84	42.1/93	52	US 52, .48 mi W SR 1 (NW junction), Area 12	Franklin	9/1		29	May-93	Per DO active slides. Old canal at toe.
85	36	52	US 52, 0.6 mi N of New Trenton	Franklin	9/20	high railrc	55	Mar-81	Inclinometers and piezometers on site installed at least as early as 3/81 Per DO monitored regularly by maint. forces. They say it's a 'shallow' failure, but SI 5201 was pinched at 24', this may be part of a larger slide.
86	41	52	US 52, 3.8 mi W of SR 46, Area 1	Franklin	9/21	engi adve	55	Feb-84	Per DO monitored regularly by maint. forces. This slide may extend through terrace to river, it may be as long as about 200'. Movement as much as 44' depth @ toe (SI 5262), this is in shale. A1 and A2 may be acting together.
87	41	52	US 52, 3.8 mi W of SR 46, Area 2	Franklin	9/21	engi cree	55	Feb-84	Per DO monitored regularly by maint. forces.This slide may extend through terrace to river, it may be as long as about 125'
88	42	52	US 52, 0.6 mi E of Old SR 1 in Cedar Grove	Franklin	9/17,18		55	Aug-83	Per file erosion problem only, per SV looked like failure. Per DO regularly monitored by maint. forces. Report says area of glacial outwash, >50' sand and gravel.
89	40	52	US 52, 6.0 mi W of SR 46	Franklin	9/19	engi cree	55	Aug-83	Per DO monitored regularly by maint. forces. Per SV 7/98, road was freshly patched.
90	108	56	SR 56, 0.6 mi N SR 156, 'Water Tower Slide'	Switzerland	11/19	GW		81	failure in weathered shale. Per DO has been basically stable. Water Co. talking about moving tower Remediation proposed for slope above road at base of water tower, did not include slope below highway
91	19	56	SR 56, 0 7 mi W of Patch Ridge Rd to SR 156	Ohio		slop men	61	Apr-90	Slide occurred during road relocation. Per DOC, corrected Original failure on emb corrected by excavation and backfill about 2 yrs ago. New LS on cutslope outside previous area Per DO stable at this time.
92	86	58	SR 58, 4.4 mi W SR 54	Greene	5/21	cree	43	Apr-88	Per DO repaired 1990.
93	1	59	SR 59 0.7 mi north Clay/Parke Co. line, A1	Parke	7/16,17		5, R78	89	Per DOC, first correction differed from that recommended in report and failed. Per DO, stone added to slope, active. In weathered shale. Per SV Soil sat @ bottom of slope even though not in low lying area.
94	1	59	SR 59 0.7 mi north Clay/Parke Co. line, A2	Parke	7/16		5, R78	89	Per DOC, first correction differed from that recommended in report and failed Per DO, stone added to slope, active. In weathered shale. Per SV Soil sat @ bottom of slope even though not in low lying area
95	107	61	SR 61, 1.4 mi S SR 62	Warrick	3/1-5	too	70	Mar-84	Per SV rip rap @ toe along ditch
96	53	62	SR 62, 0 1 mi W SR 145	Perry	2/1-4	cree engi	24	Apr-66	Per DO active, INDOT wedges once/yr, est cost of repair=$1Million; wedge cost=$1000/yr;INDOT will continue to wedge.
97	83	62	SR 62, 0.1 mi E SR 250 (NE junction)	Jefferson	12/2	cree bed	68	Aug-83	Per DO corrected by maintenance contract.
98	60	62	SR 62, 0.5 mi E SR 131, Area 2 across from A-1	Clark	8/22	too		Sep-84	Per DO repairs by maint. forces, areas seem stable.
99	60	62	SR 62, 0.5 mi E SR 131, Area 1 across from A-2	Clark	8/21	too		Sep-84	Per DO repairs by maint. forces, areas seem stable.
100	57	62	SR 62, 0.5 mi E St. Meinrad	Spencer	2/20,21	bed rem	82, 83	May-05	Inclinometer installed 8/83. Initial failure '75, reportedly from ditching.
101	84/105	62	SR 62, 0.8 mi E SR 66 (W junction near Sulphur)	Crawford		engi bed	94	Mar-84	Per DOC, area was corrected on new bridge project. Per DO correction complete.
102	new	62	SR 62, 1.4 mi E SR 162	Spencer	2/22,23		30	98	Per DO guardrail slipping, priority.
103	4	62	SR 62, 2.9 mi E of SR 3	Clark	8/20	cree prob	35, 87	Sep-95	Per DOC, district make shift correction failed. Per DO district forces wedge, level and monitor area-active.
104	216	63	SR 63, 0.2 mi S Tecumsen-New Gashem Rd.	Vigo	7/15	clog infilt	74	Dec-87	Per DO didn't find where problem was. Per SV rip rap @ shoulder and AP patches.
105	82	63	SR 63, 7.9 mi S SR 163, Area 1	Vigo	7/13	faile	4, R82	Nov-87	Per DO maintenance tried to stabilize but not very successful, continues to slide. Per SV gully wash/piping @ pipe running W down hill.
106	82	63	SR 63, 7.9 mi S SR 163, Area 2	Vigo	7/14	faile	4, R82	Nov-87	Per DO maintenance tried to stabilize but not very successful, continues to slide.
107	29	64	SR 64, 0.2 mi W of SR 145	Crawford	4/19,20	GW	30	Jul-86	Per DO not a priority.
108	79	64	SR 64, 1.1 mi W SR 37, Area 1	Crawford	5/2	GW	56	Aug-86	Per DO small and stable.
109	79	64	SR 64, 1.1 mi W SR 37, Area 2	Crawford	5/3	GW	56	Aug-86	Per DO small and stable.
110	79	64	SR 64, 1.1 mi W SR 37, Area 3	Crawford	5/4	GW	56	Aug-86	Per DO small and stable.
111	77	64	SR 64, 2.2 mi E SR 37	Crawford	4/18	too	56	Jan-86	Per DO small and stable, not a priority. Per SV corrected but possibly still moving, cracks in pavement on N side of road.
112		64.1	7.2 EB	Warrick	14/12		66	Sep-82	
113	106	64.1	20.5 WB	Vanderburgh	14/10	too	66	Jan-90	multiple small slides here
114	106	64.1	20.6 EB	Vanderburgh	14/11	too	66	Sep-82	multiple small slides here
115	106	64.1	20.6 EB	Vanderburgh	14/11	too	66	Sep-82	multiple small slides here
116	106	64.1	20.6 WB	Vanderburgh	14/10	too	66	Sep-82	multiple small slides here
117	106	64.1	22.4 EB	Vanderburgh	14/8	too	66	Jan-90	
118	106	64.1	22.4 WB	Vanderburgh	14/9	too	66	Sep-82	

LANDSLIDE INVENTORY

ID	File	Roadway	Location	County	photo log log/pic	Probable Cause	Remedial Method	Vegetation	Correction status	Landslide type	Slope type	Bedrock type	Failure position	GEOMETRIC INFORMATION: Slope (°)	W ft	L ft	plan area ft²	D ft	OB (range) ft	OB (avg) ft	volume yds³	DATA AVAILABLE: Field sketch	Borelogs	Slope inc.	Initial date of road construction	Earliest reported date of failure	Miscellaneous Comments
78	42 1/93	52	US 52, 1.09 mi W SR 1 (NW junction), Area 6	Franklin	9/6		rock backfill	dt	nc		e	o3	U1/4	30	90	50	3,534					y	n	n	29	May-93	Per DO active slides. Old canal at toe.
79	42.1/93	52	US 52, 0.98 mi W SR 1 (NW junction), Area 7	Franklin	9/7			dt	nc		e	o3	E	29	315	160	39,584					y	n	n	29	May-93	Per DO active slides. Old canal at toe.
80	42 1/93	52	US 52, 0 73 mi W SR 1 (NW junction), Area 8	Franklin	9/3,4	drainage outlet adjacent to failure, engineering of fill, sloping bedrock, adverse GW conditions	bin wall or reinforced earth wall	dt	nc		e	o3	U1/2	30	292	107	24,539		32-42	37		y	y	n	29	May-93	Per DO active slides Old canal at toe
81	42 1/93	52	US 52, 0.67 mi W SR 1 (NW junction), Area 9	Franklin	9/5	engineering of fill, sloping bedrock, adverse GW conditions	bin wall or reinforced earth wall	dt	nc		e	o3	U1/2	30	181	131	18,623		25-42	34		y	y	y	29	Oct-85	Per DO active slides. Old canal at toe. Thick sandy gravel layers in subsurface
82	42 1/93	52	US 52, 0 60 mi W SR 1 (NW junction), Area 10	Franklin		engineering of fill, sloping bedrock	bin wall or reinforced earth wall		nc		e	o3	E	26	250	190	37,306		<25	25		y	n	n	29	May-93	Per DO active slides Old canal at toe Thick sandy gravel layers in subsurface Failure looks regressive
83	42.1/93	52	US 52, 0.51 mi W SR 1 (NW junction), Area 11	Franklin	9/2		rock backfill	db-dt	nc		c	o3	L1/4	22	150	25	2,945					y	n	n	29	May-93	Per DO active slides Old canal at toe
84	42.1/93	52	US 52, 48 mi W SR 1 (NW junction), Area 12	Franklin	9/1		bin wall or reinforced earth wall	d-vdt	nc		e	o3	E	31	735	135	77,931					y	n	n	29	May-93	Per DO active slides Old canal at toe
85	36	52	US 52, 0 6 mi N of New Trenton	Franklin	9/20	high GW table, removal of toe by railroad, sloping bedrock	temp wall using driven RR rails failed, report recomm. drilled pier wall	vdg, m-vdt	nc		e	o2	E	34	273	31	6,647	30	20-40	30	4,924	y	n	y	55	Mar-81	Inclinometers and piezometers on site installed at least as early as 3/81. Per DO monitored regularly by maint. forces. They say it's a 'shallow' failure, but SI 5201 was pinched at 24', this may be part of a larger slide
86	41	52	US 52, 3 8 mi W of SR 46, Area 1	Franklin	9/21	engineering of fill, sloping bedrock adverse GW conditions, creek @ toe	drilled pier wall w/ rock fill downslope from wall	m-vdt	nc	es-r	e	o3	U1/2	32	184	71	10,260	44	20-36	28	11,147	y	y	y	55	Feb-84	Per DO monitored regularly by maint. forces. This slide may extend through terrace to river, it may be as long as about 200' Movement as much as 44' depth @ toe (SI 5262), this is in shale. A1 and A2 may be acting together
87	41	52	US 52, 3.8 mi W of SR 46, Area 2	Franklin	9/21	engineering of fill, sloping bedrock creek @ toe	drilled pier wall w/ rock fill downslope from wall	m-vdt	nc	es-r	e	o2	E	32	258	65	13,070	30	24-29	27	9,681	y	y	y	55	Feb-84	Per DO monitored regularly by maint. forces This slide may extend through terrace to river, it may be as long as about 125'
88	42	52	US 52, 0 6 mi E of Old SR 1 in Cedar Grove	Franklin	9/17,18			dg, dt near toe	nc		e	o2	E	31	350	80	21,991		>50	50		y	n	n	55	Aug-83	Per file erosion problem only, per SV looked like failure Per DO regularly monitored by maint forces. Report says area of glacial outwash, >50' sand and gravel
89	40	52	US 52, 6.0 mi W of SR 46	Franklin	9/19	engineering of fill, sloping bedrock, creek @ toe	rock backfill	d-vdt	nc	es-r	e	o2	U1/2	26	500	70	27,489	17	10-21	16	11,539	y	y	n	55	Aug-83	Per DO monitored regularly by maint. forces Per SV 7/98, road was freshly patched
90	108	56	SR 56, 0.6 mi N SR 156, 'Water Tower Slide'	Switzerland	11/19	GW weakened shale	Drilled piers w/ tie backs into rock considered	vdt	nc	es-r	e/c	o2	M1/?	17-26	285	225	50,364	20	10-25	18	24,871	y	y	n		81	failure in weathered shale Per DO has been basically stable Water Co talking about moving tower Remediation proposed for slope above road at base of water tower, did not include slope below highway
91	19	56	SR 56, 0 7 mi W of Patch Ridge Rd to SR 156	Ohio		sloping bedrock, creek @ toe (not mentioned as probable cause)	relocated road, considered rock backfill	dg, m-dt	c	es-r	e	o2	E	13	755	240	142,314	8	5-10	8	26,354	y	y	n	61	Apr-90	Slide occurred during road relocation. Per DOC, corrected. Original failure on emb corrected by excavation and backfill about 2 yrs ago New LS on cutslope outside previous area Per DO stable at this time.
92	66	58	SR 56, 4 4 mi W SR 54	Greene	5/21	creek erosion of toe	rock backfill	vdb	c	es	e	m3	E	29	137	40	4,304	10	50	50	1,063	y	n	n	43	Apr-88	Per DO repaired 1990.
93	1	59	SR 59 0 7 mi north Clay/Parke Co line, A1	Parke	7/16,17			dt, vdg	nc		e	p1	E	26	50	45	1,767		15-25	20		y	y	n	55, R78	89	Per DOC, first correction differed from that recommended in report and failed Per DO, stone added to slope, active. In weathered shale. Per SV Soil sat @ bottom of slope even though not in low lying area
94	1	59	SR 59 0 7 mi north Clay/Parke Co line, A2	Parke	7/16		rock backfill	dt, vdg outside r/r	cne		e	p1	E	24	85	55	3,672		8-20	15		y	y	n	55, R78	89	Per DOC, first correction differed from that recommended in report and failed Per DO, stone added to slope, active In weathered shale. Per SV Soil sat @ bottom of slope even though not in low lying area
95	107	61	SR 61, 1 4 mi S SR 62	Warrick	3/1-5	too steep	rock backfill w and w/o B borrow	vdg	nc		c	p2	E	20	460	70	25,290		50-100	75		y		n	70	Mar-84	Per SV rip rap @ toe along ditch
96	53	62	SR 62, 0 1 mi W SR 145	Perry	2/1-4	creek @ toe, GW @ s/r interface, engineering of fill	rock backfill, slope flattening and drainage	dg, dt @ and beyond toe	nc		e	m6	E	16	260	110	24,190	20	<20	20	11,846	n	n	n	24	Apr-66	Per DO active, INDOT wedges once/yr, est cost of repair=$1Million; wedge cost=$1000/yr;INDOT will continue to wedge.
97	83	62	SR 62, 0 1 mi E SR 250 (NE junction)	Jefferson	12/2	creek erosion of toe, too steep, sloping bedrock	retaining wall, report recommended rock backfill	vdb above wall; dt flanking wall	c	es-r	e	o3	E		250	50	9,817		<30	30	7,272	y	n	n	68	Aug-83	Per DO corrected by maintenance contract.
98	60	62	SR 62, 0 5 mi E SR 131, Area 2 across from A-1	Clark	8/22	too steep	rock backfill	st outside r/r	c	es	e	O	U3/4	36	200	55	8,639		<75	75		y	n	n		Sep-84	Per DO repairs by maint. forces, areas seem stable
99	60	62	SR 62, 0 5 mi E SR 131, Area 1 across from A-2	Clark	8/21	too steep	rock backfill	dt, vdb outside r/r	c	es	e	D	U3/4	27	215	60	10,132		<75	75		y	n	n		Sep-84	Per DO repairs by maint. forces, areas seem stable
100	57	62	SR 62, 0.5 mi E St. Meinrad	Spencer	2/20,21	bedrock slope, GW @ s/r interface, removal of toe bulge	binwall @ scarp, rock backfill within failed area	vdt	nc	es-r	c	m6	L1/?	19	155	140	17,643	13	5-60	33	5,471	y	y	y	82, 83	May-05	Inclinometer installed 8/83 Initial failure '75, reportedly from ditching
101	84/105	62	SR 62, 0 8 mi E SR 66 (W junction near Sulphur)	Crawford		engineering of fill, drainage, sloping bedrock	rock backfill, corrected with new bridge		c	es-r	e	m4	U1/?		152	86	10,267	12	5-12	9	3,042	y	y	n	94	Mar-84	Per DOC, area was corrected on new bridge project Per DO correction complete
102	new	62	SR 62, 1.4 mi E SR 162	Spencer	2/22,23			vdt mid slope, dg, scarp in road	nc		e	p1	U1/2	35								n	n	n	30	98	Per DO guardrail slipping, priority
103	4	62	SR 62, 2.9 mi E of SR 3	Clark	8/20	creek at toe (not mentioned as probable cause), sloping bedrock	rock backfill still failing	sg-sb w/in r/r, dt @ toe	cne		e	o4	E	27	175	105	14,432	17	34	34	6,058	y	y	n	35, 87	Sep-95	Per DOC, district make shift correction failed. Per DO district forces wedge, level and monitor area-active
104	216	63	SR 63, 0.2 mi S Tecumseh-New Goshem Rd	Vigo	7/15	clogging of CMP, curb broken allowing infiltration of runoff	rip rap and AP patches	vdg, sst	c		e	p3	E	32	73	30	1,720		<40	30		y	n	n	74	Dec-87	Per DO didn't find where problem was. Per SV rip rap @ shoulder and AP patches
105	82	63	SR 63, 7.9 mi S SR 163, Area 1	Vigo	7/13	failed pipes may have saturated slope	rip rap	vdb, sst	pc		e	p3	E	29	80	75	4,712		<15	10		y	n	n	74, R82	Nov-87	Per DO maintenance tried to stabilize but not very successful, continues to slide. Per SV gully washing @ pipe running W down hill.
106	82	63	SR 63, 7 9 mi S SR 163, Area 2	Vigo	7/14	failed pipes may have saturated slope		dg, st outside r/r	nc		e	p3	E	27	75	65	3,829		<15	10		y	n	n	74, R82	Nov-87	Per DO maintenance tried to stabilize but not very successful, continues to slide.
107	29	64	SR 64, 0.2 mi W of SR 145	Crawford	4/19,20	GW @ s/r interface	rock backfill	dt outside of LS, db w/in LS	nc	es-r	c	p1	E	23	230	43	7,768	6	5-15	10	1,151	y	n	n	30	Jul-86	Per DO not a priority.
108	79	64	SR 64, 1 1 mi W SR 37, Area 1	Crawford	5/2	GW @ s/r interface	rock backfill	vdg	c	es-r	c	m5	M1/2	22	125	125	12,272	12	5-10	8	3,636	y	y	n	56	Aug-86	Per DO small and stable
109	79	64	SR 64, 1.1 mi W SR 37, Area 2	Crawford	5/3	GW @ s/r interface	rock backfill	vdg, b, st	nc	es-r	c	m5	E	11	700	163	89,614	12	5-10	8	26,552	y	y	n	56	Aug-86	Per DO small and stable
110	79	64	SR 64, 1.1 mi W SR 37, Area 3	Crawford	5/4	GW @ s/r interface	rock backfill	vdg, s-dt above r/r	c	es-r	c	m5	L1/2	20	175	50	6,872	6	5-10	8	1,018	y	y	n	56	Aug-86	Per DO small and stable.
111	77	64	SR 64, 2 2 mi E SR 37	Crawford	4/18	too steep	rock backfill	dt outside r/r	c	es-r	e	m5	E	31	260	90	18,378	25	25	25	11,345	y	y	n	56	Jan-86	Per DO small and stable, not a priority. Per SV corrected but possibly still moving, cracks in pavement on N side of road.
112		64 1	7.2 EB	Warrick	14/12		regraded?	dg; mt @ top of slope	c	es	c	p4		22	150	60	7069		200	200		n	n		66	Sep-82	
113	106	64 1	20.5 WB	Vanderburgh	14/10	too steep		vdb, st	nc	es	c	p3	E	23	200	30	4712		50-100	75		y	n		66	Jan-90	multiple small slides here
114	106	64 1	20 6 EB	Vanderburgh	14/11	too steep		vdb	nc	es	c	p3	E	27	30	30	707		50-100	75		y	n		66	Sep-82	multiple small slides here
115	106	64 1	20 6 EB	Vanderburgh	14/11	too steep		vdb	nc	es	c	p3	E	27	250	30	5890		50-100	75		y	n		66	Sep-82	multiple small slides here
116	106	64 1	20 6 WB	Vanderburgh	14/10	too steep		vdb, st	nc	es	c	p3	E	23	430	30	10132		50-100	75		y	n		66	Sep-82	multiple small slides here
117	106	64 1	22 4 EB	Vanderburgh	14/8	too steep	rock backfill	dg outside r/r, st @ fence line	c	es	c	p3	E	25	60	30	1885		50-100	75		y	n		66	Jan-90	
118	106	64 1	22 4 WB	Vanderburgh	14/9	too steep	rock backfill	db outside r/r, st @ fence line	c	es	c	p3	E	26	110	35	3024		50-100	75		y	n		66	Sep-82	

ID	File	Roadway	Location	County	photo log log/pic		date of ad ruction	Earliest reported date of failure	Miscellaneous Comments
119	106	64.1	22.7 WB	Vanderburgh	14/6	too	66	Sep-82	
120	106	64.1	22.8 EB	Vanderburgh	14/7	acc allo	66	Sep-82	
121	106	64.1	22.8 WB	Vanderburgh	14/6	too	66	Jan-90	
122	106	64.1	23.3 EB	Vanderburgh	14/5	too	66	Jan-90	
123		64.1	23.3 WB	Vanderburgh	14/4		66		
124	106	64.1	23.7 EB	Vanderburgh	14/3	too	67	Jan-90	
125	106	64.1	23.7 WB	Gibson	14/2	too	67	Jan-90	
126	106	64.1	23.79 WB, Area 1	Gibson	14/2	too	67	Apr-93	
127	106	64.1	23.79 WB, Area 2	Gibson	14/2	too	67	Apr-93	
128	106	64.1	23.8 WB	Gibson	14/2	too	67	Jan-90	
129	106	64.1	24.15 EB, Area 1	Vanderburgh	14/13	engi	67	Apr-93	
130	106	64.1	24.15 EB, Area 2	Vanderburgh	14/13	engi	67	Apr-93	
131	106	64.1	24.15 EB, Area 3	Vanderburgh	14/13	engi	67	Apr-93	
132	27	64.1	62.2 EB	Dubois	14/1	GW	72	Oct-82	
133		64.1	63.4 WB	Dubois	13/23	GW	72	Jun-85	Per SV no apparent sign of failure
134	27	64.1	64.6 EB	Spencer	13/24	GW	72	Oct-82	
135	27	64.1	68.5 EB	Perry	13/22	faile	73	Jun-82	
136	27	64.1	70.1 EB	Perry	13/21	GW	73	Oct-82	
137		64.1	72.9 MED, Area 1	Perry	13/18	GW	73	Oct-82	Per SV no apparent sign of failure
138	27	64.1	72.9 MED, Area 2	Perry	13/18	GW	73	Oct-82	Per SV no apparent sign of failure
139		64.1	73.1 EB	Perry	13/17	too	73	Jul-85	
140	27	64.1	73.2 WB	Perry	13/15	GW	73	Oct-82	
141	27	64.1	73.3 EB, Area 1	Perry	13/19	GW	73	Oct-82	
142	27	64.1	73.3 EB, Area 2	Perry	13/19	GW	73	Oct-82	
143		64.1	73.5 EB	Perry	13/16	GW	73	Dec-82	
144	27	64.1	73.5 EB MEDIAN	Perry	13/16	faile	73	Feb-87	
145		64.1	73.8 EB	Perry	13/20	too	73	Dec-82	
146		64.1	75.4 EB	Perry	13/13	GW	73	Nov-86	
147		64.1	75.5 WB	Perry			73		Per SV didn't see landslide
148	27	64.1	75.7 WB	Perry	13/14	GW	73	Oct-82	Per SV no apparent sign of failure
149	27	64.1	76.8 EB	Perry	13/12	GW	73	Oct-82	Per SV no apparent sign of failure
150		64.1	78.4 WB	Perry	13/11	too	73	Jul-86	Per SV no apparent sign of failure
151		64.1	78.7 EB	Perry	13/10		73	Jul-85	
152	27	64.1	79.9 WB	Crawford	13/6	GW	73	Oct-82	Per SV no apparent sign of failure
153		64.1	80.0 WB	Crawford	13/5		73	Oct-86	
154	27	64.1	80.2 EB	Crawford	13/7,8	GW	73	Oct-82	In rest area
155	27	64.1	80.5 WB	Crawford		GW	73	Oct-82	
156	27	64.1	80.7 WB	Crawford		GW	73	Oct-82	
157		64.1	80.9 WB	Crawford	13/4		73	Jan-87	
158		64.1	81.6 EB	Crawford	13/9	GW	73	Feb-87	Per SV no apparent sign of failure
159		64.1	81.7 EB	Crawford		GW	73	Feb-87	Per SV no apparent sign of failure
160		64.1	83.2 WB	Crawford	13/3	GW	73	Mar-87	
161	27	64.1	83.3 EB	Crawford	13/1	GW	73	Oct-82	
162	27	64.1	83.3 WB	Crawford	13/3	GW	73	Sep-82	
163	27	64.1	83.4 EB	Crawford	13/2	GW	73	Sep-82	
164	27	64.1	83.8 WB	Crawford	12/20,21	too GW	73	Oct-82	

LANDSLIDE INVENTORY

														GEOMETRIC INFORMATION								DATA AVAILABLE					
ID	File	Roadway	Location	County	photo log log/pic	Probable Cause	Remedial Method	Vegetation	Correction status	Landslide type	Slope type	Bedrock type	Failure position	Slope (°)	W ft	L ft	plan area ft^2	D ft	OB (range) ft	OB (avg) ft	volume yds^3	Field sketch	Borelogs	Slope inc.	Initial date of road construction	Earliest reported date of failure	Miscellaneous Comments
119	106	64 1	22.7 WB	Vanderburgh	14/6	too steep	rock backfill	dg outside r/r; cornfield @ top; st @ fence row	c	es	c	p3	E	24	105	35	2886		50-100	75		y	n		66	Sep-82	
120	106	64 1	22 8 EB	Vanderburgh	14/7	access rd ditch too close to top allowing GW infiltration	rock backfill	vdb outside r/r, rt @ fence line	c	es	c	p3	E	23	60	35	1649		50-100	75		y	n		66	Sep-82	
121	106	64 1	22 8 WB	Vanderburgh	14/6	too steep	rock backfill	dg outside r/r; cornfield @ top; st @ fence row	c	es	c	p3	E		222	35	6103		50-100	75		y	n		66	Jan-90	
122	106	64 1	23 3 EB	Vanderburgh	14/5	too steep	rock backfill	vdb outside r/r, st @ fence line	c	es	c	p3	E	25	110	35	3024		50-100	75		y	n		66	Jan-90	
123		64 1	23 3 WB	Vanderburgh	14/4		rock backfill	vdb, sst	nc	es	c	p3	E	26								y	n		66		
124	106	64 1	23.7 EB	Vanderburgh	14/3	too steep	rock backfill	vdb outside r/r, rt @ fence row; cornfield @ top	c	es	c	p3	E	23	100	50	3927		50-100	75		y	n		67	Jan-90	
125	106	64 1	23 7 WB	Gibson	14/2	too steep	rock backfill	dg outside r/r, cornfield @ top	c	es	c	p3	E	22	140	45	4948		50-100	75		y	n		67	Jan-90	
126	106	64.1	23.79 WB, Area 1	Gibson	14/2	too steep	rock backfill	dg outside r/r, cornfield @ top	c	es	c	p3	L3/4	26	70	30	1649		50-100	75		n	n		67	Apr-93	
127	106	64 1	23 79 WB, Area 2	Gibson	14/2	too steep	rock backfill	dg outside r/r, cornfield @ top	c	es	c	p3	L3/4	26	70	30	1649		50-100	75		n	n		67	Apr-93	
128	106	64 1	23.8 WB	Gibson	14/2	too steep	rock backfill	dg outside r/r, cornfield @ top	c	es	c	p3	L3/4	26	230	35	6322		50-100	75		n	n		67	Jan-90	
129	106	64 1	24 15 EB, Area 1	Vanderburgh	14/13	engineering of fill	rock backfill	dg outside r/r; st and cornfield @ toe	c	es	e	p3	M2/3	28	30	25	589		50-100	75		n	n		67	Apr-93	
130	106	64 1	24 15 EB, Area 2	Vanderburgh	14/13	engineering of fill	rock backfill	dg outside r/r; st and cornfield @ toe	c	es	e	p3	E	28	220	35	6048		50-100	75		n	n		67	Apr-93	
131	106	64 1	24 15 EB, Area 3	Vanderburgh	14/13	engineering of fill	rock backfill	dg outside r/r; st and cornfield @ toe	c	es	e	p3	L3/4	28	40	31	974		50-100	75		n	n		67	Apr-93	
132	27	64 1	62 2 EB	Dubois	14/1	GW @ s/r interface		dg, vdb, dst	nc	es-r	c	p1	L1/2	25	70	35	1924		0-6	3	143	y	y		72	Oct-82	
133		64 1	63.4 WB	Dubois	13/23	GW @ s/r interface	regraded?	dg, st @ fence row		es-r	c	p1	E	22	75	50	2945		3-7	5	364	y	y		72	Jun-85	Per SV no apparent sign of failure
134	27	64 1	64 6 EB	Spencer	13/24	GW @ s/r interface		db w/in LS, dg outside LS, m-dt @ top	nc	es-r	c	p1	M3/4	20	60	65	3063		<10	10	756	y	y		72	Oct-82	
135	27	64 1	68 5 EB	Perry	13/22	failed CPID	rock backfill	dg outside r/r; dt @ upper limit of r/r	c	es-r	c	p1	L1/?	19	70	51	2804		1-3	2	138	y	y		73	Jun-82	
136	27	64 1	70 1 EB	Perry	13/21	GW seeping from hill, erosion	rock backfill	dg outside r/r; db, dt @ top slope	c	es-r	c	m6	L1/3	22	425	60	20028		3-15	9	4,451	y	y		73	Oct-82	
137		64 1	72 9 MED, Area 1	Perry	13/18	GW seeping from hill	regraded?	dg		es-r	e	m6	E		100	45	3534		3-9	6	524	y	y		73	Oct-82	Per SV no apparent sign of failure
138	27	64 1	72 9 MED, Area 2	Perry	13/18	GW seeping from hill	regraded?	dg		es-r	e	m6	E	8	70	37	2034		3-9	6	301	y	y		73	Oct-82	Per SV no apparent sign of failure
139		64 1	73.1 EB	Perry	13/17	too steep	rock backfill	dg outside r/r, dt top slope	c	es-r	c	m6	L1/2	17	120	70	6597		<10	10	1,629	y	y		73	Jul-85	
140	27	64 1	73 2 WB	Perry	13/15	GW seeping from hill		dg outside r/r; db w/in r/r; dt @ top	nc	es-r	c	m6	M1/4	19	75	55	3240		3-13	8	640	y	y		73	Oct-82	
141	27	64 1	73 3 EB, Area 1	Perry	13/19	GW seeping from hill, erosion	rock backfill	dg outside r/r; dt @ upper limit of r/r	c	es-r	c	m6	E	22	105	100	8247		5	5	1,018	y	y		73	Oct-82	
142	27	64 1	73.3 EB, Area 2	Perry	13/19	GW seeping from hill, erosion	rock backfill	dg outside r/r; dt @ upper limit of r/r	c	es-r	c	m6	E	22	75	40	2356		3-6	5	262	y	y		73	Oct-82	
143		64 1	73.5 EB	Perry	13/16	GW seeping from hill, erosion	rock backfill	dg outside r/r; dt @ top	c	es-r	c	m6	M1/3	18	105	40	3299		3-9	6	489	y	y		73	Dec-82	
144	27	64 1	73 5 EB MEDIAN	Perry	13/16	failed CPID	rock backfill	dg outside r/r	c	es-r	e	m6	L3/4	21	75	60	3534		6-10	8	698	y	y	y	73	Feb-87	
145		64 1	73 8 EB	Perry	13/20	too steep	rock backfill	dg outside r/r; dt just above r/r	c	es-r	c	m6	L1/?	18	120	70	6597		2-11	7	1,059	y	y		73	Dec-82	
146		64 1	75 4 EB	Perry	13/13	GW @ s/r interface	rock backfill	dg outside r/r; mt @ top slope	c	es-r	c	m6	M1/2	18	215	52	8781		3-5	4	867	y	y		73	Nov-86	
147		64 1	75.5 WB	Perry						es-r	c	m6										n	n		73		Per SV didn't see landslide
148	27	64 1	75.7 WB	Perry	13/14	GW seeping from hill	regraded?	dg, dt @ top slope		es-r	c	m6	L1/?		100	40	3142		0-3	2	116	y	y		73	Oct-82	Per SV no apparent sign of failure
149	27	64 1	76 8 EB	Perry	13/12	GW seeping from hill	regraded?	dg, dt @ top slope		es-r	c	m6	U1/2		110	60	5184		1-4	3	320	y	y		73	Oct-82	Per SV no apparent sign of failure
150		64.1	78 4 WB	Perry	13/11	too steep	regraded?	dg		es-r	c	m6	U3/4	19	75	45	2651		3-10	7	425	y	y		73	Jul-86	Per SV no apparent sign of failure
151		64 1	78 7 EB	Perry	13/10		rock backfill	dg outside r/r	c	es-r	e	m6	L3/4		27	40	848		3-21	12	251	y	y		73	Jul-85	
152	27	64 1	79.9 WB	Crawford	13/6	GW seeping from hill	regraded?	dg, dt @ top slope		es-r	c	m6	L1/?	13	75	37	2179		3-6	5	242	y	y		73	Oct-82	Per SV no apparent sign of failure
153		64 1	80.0 WB	Crawford	13/5			dg outside LS, vdb w/in LS, dt @ top slope	nc	es-r	c	m6	M1/3	20	140	50	5498		3-6	5	611	y	y		73	Oct-86	
154	27	64 1	80 2 EB	Crawford	13/7,8	GW seeping from hill		dg outside LS, vdb w/in LS	nc	es-r	c	m6	M1/?	27	145	82	9338		3-12	8	1,729	y	y		73	Oct-82	in rest area
155	27	64 1	80.5 WB	Crawford		GW seeping from hill				es-r	c	m6	M3/4	18	200	60	9425		2-3	3	582	y	y		73	Oct-82	
156	27	64,1	80 7 WB	Crawford		GW seeping from hill				es-r	c	m6	E	19	400	110	34558		1-2	2	1,280	y	y		73	Oct-82	
157		64.1	80 9 WB	Crawford	13/4			dg	nc	es-r	c	m6	L1/?	16	130	70	7147		4-8	6	1,059	y	y		73	Jan-87	
158		64 1	81.6 EB	Crawford	13/9	GW @ s/r interface	regraded?	dg; dt @ top slope		es-r	c	m5	U2/3	18	160	60	7540		5-18	12	2,141	y	y		73	Feb-87	Per SV no apparent sign of failure
159		64 1	81.7 EB	Crawford		GW @ s/r interface				es-r	c	m5	U1/4		180	55	7775		7-8	8	1,440	y	y		73	Feb-87	Per SV no apparent sign of failure
160		64 1	83 2 WB	Crawford	13/3	GW @ s/r interface		dg, st, dt @ top slope	nc	es-r	c	m6	L1/?		85	75	5007		1-10	5	556	y	y		73	Mar-87	
161	27	64 1	83 3 EB	Crawford	13/1	GW seeping from hill		dg, db; mt @ top slope	nc	es-r	c	m6	E	20	200	60	9425		2	2	465	y	y	y	73	Oct-82	
162	27	64 1	83 3 WB	Crawford	13/3	GW seeping from hill, erosion		dg, st, dt @ top slope	nc	es-r	c	m6	U2/3	18	125	90	8836		1-6	4	764	y	y		73	Sep-82	
163	27	64 1	83 4 EB	Crawford	13/2	GW seeping from hill		dg, vdb, dt @ top of slope	nc	es-r	c	m6	L1/?	20	160	80	10053		1-5	3	745	y	y		73	Sep-82	
164	27	64 1	83 8 WB	Crawford	12/20,21	too steep, terrace above slide allowed GW infiltration		dg w/in LS; m-dt outside LS	nc	es-r	e	m5	U1/2		160	130	16336		8	8	3,227	y	y		73	Oct-82	

ID	File	Roadway	Location	County	photo log log/pic		date of ad ruction	Earliest reported date of failure	Miscellaneous Comments
165		64.1	84.2 WB	Crawford	12/19	too s	73	Jan-87	SV was in incorrect location
166	27	64.1	85.2 MED	Crawford	12/18	GW	73	Sep-82	
167		64.1	85.2 WB	Crawford	12/17	GW	73	Feb-87	
168	27	64.1	85.8 EB	Crawford	12/11	GW	73	Sep-82	
169	27	64.1	87.0 EB	Crawford	12/12	failed	73	Oct-82	
170		64.1	88.5 EB	Crawford	12/14	too s	73	Jun-86	
171	27	64.1	88.7 EB	Crawford	12/13	GW	73	Sep-82	
172		64 1	89.1 EB	Crawford	12/15		73	Feb-87	
173	27	64.1	89 4 WB	Crawford	12/10	CMP seep	73	Sep-82	SV was in incorrect location
174	27	64 1	89.5 EB	Crawford	12/16	GW	73	Sep-82	
175	27	64 1	89.5 WB	Crawford	12/8,9	failed	73	Jun-82	
176	27	64 1	89.8 WB	Crawford	12/7	GW	73	Sep-82	Per SV no apparent sign of failure
177	new	64 1	92, Exit 92, NW ramp.	Crawford	1/6,7		72	98	
178		64 1	96.4 EB	Crawford	12/5,6	too s	'4, R94	Dec-85	Per SV appeared to be erosion only, erosion of cpsd. Per DO maint. forces have placed rip rap.
179	27/78	64 1	118.1 EB	Floyd	12/4	too s	'4, R95	Dec-85	Per DO maint. forces have placed rip rap and monitor these places regularly
180	71	65	SR 65, 2.34 mi N SR 64	Gibson	3/19,20	inade GW	55	Jan-86	Per DO continually active, NBL requires yearly wedges, settles 2"/yr.
181	220	65 1	I-65, 2.4 mi S Clark/Scott line, Area 2 across from A-4	Clark	8/16,17	failed toe, here	58-59	Oct-87	Per DO repaired by state forces.
182	220	65 1	I-65, 2.4 mi S Clark/Scott line, Area 3 across from A-1	Clark	8/18,19	failed toe, CMP	58-59	Oct-87	Per DO repaired by state forces.
183	220	65.1	I-65, 2.4 mi S Clark/Scott line, Area 4 across from A-2	Clark	8/18,19	failed engi runs	58-59	Oct-87	Per DO repaired by state forces.
184	58	66	SR 66, 4.6 mi W SR 70, Area 1	Spencer	8/7	slop	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically.
185	58	66	SR 66, 4 4 mi W SR 70, Area 2	Spencer	8/6	slop	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically.
186	58	66	SR 66, 2.3 mi W SR 70, Area 3	Spencer	8/4,5	slop	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically.
187	58	66	SR 66, 2.1 mi W SR 70, Area 4a	Spencer		slop	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically.
188	58	66	SR 66, 2.1 mi W SR 70, Area 4b	Spencer	8/3	slop	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically
189	58	66	SR 66, 2.1 mi W SR 70, Area 4c	Spencer		slop	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically
190	58	66	SR 66, 1.3 mi W SR 70, Area 5	Spencer	7/2	slop	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically.
191	58	66	SR 66, 1.15 mi W SR 70, Area 6	Spencer	7/1	slop	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically.
192	58	66	SR 66, 0.95 mi W SR 70, Area 7	Spencer	7/24	clear sprin	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically.
193	58	66	SR 66, .80 mi W SR 70, Area 8	Spencer	7/23	slop	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically
194	224	66	SR 66, 0.2 mi E SR 70	Spencer	7/4,5	cree	86	Oct-85	
195	104	66	SR 66, 0.3 mi E of SR 545	Perry	2/10-13	poss	40, 49	92	Old coal mine underneath site. Per DOC reevaluation in progress. Per DO slide stable until 3/97 flood, cracking currently, requires R/W to repair.
196	223	66	SR 66, 6.3 mi N SR 70	Perry	1/11,12	eros	79	Sep-91	Engr.Report dated 1/97 discussing various remediation techniques and costs. Per DO currently being repaired by contract
197	15	66	SR 66, 2.6 S of SR 64	Crawford	1/1-5		68	Oct-89	Per DO mostly erosion, partial repair by INDOT. Road may have been realigned through area. Per SV landslides may not be same ones as described in file.
198	70	70	SR 70, 0.1 mi W SR 66, Area 1	Spencer	2/16,17	cree	'4, W68	Mar-84	
199	70	70	SR 70, 0.1 mi W SR 66, Area 2	Spencer	2/14,15	cree	'4, W68	Mar-84	
200	70	70	SR 70, 0.1 mi W SR 66, Area 3	Spencer	2/18	cree	'4, W68	Mar-84	Per DO slide active, pushing on NE corner of endbent of STR 70-74-26A, requires ditching 2/yr.
201	69	70.1	I-70, 0.1 mi E SR 243	Putnam		slop	65, R86	Mar-86	Per DO no maintenance done @ location, does not seem to be an active landslide, no immediate concern.
202		74.1	155.4 EB	Ripley	14/14	too s	62	Jul-87	
203		74.1	156.0 WB	Ripley	14/15	too s	62	Apr-86	
204		74 1	156.6 EB, Area 1	Ripley	14/16	too s	62	Jun-85	
205		74.1	156.6 EB, Area 2	Ripley	14/16	too s	62	Jun-85	
206		74.1	159.7 EB	Dearborn	14/17,18	too s	62	Jul-85	Underlain by limestone bedrock.
207		74.1	160.5 WB	Dearborn	14/19	too s	62	Apr-86	

LANDSLIDE INVENTORY

ID	File	Roadway	Location	County	photo log log/pic	Probable Cause	Remedial Method	Vegetation	Correction status	Landslide type	Slope type	Bedrock type	GEOMETRIC INFORMATION: Failure position	Slope (°)	W ft	L ft	plan area ft²	O ft	OB (range) ft	OB (avg) ft	volume yds³	DATA AVAILABLE: Field sketch	Borelogs	Slope inc.	Initial date of road construction	Earliest reported date of failure	Miscellaneous Comments
165		64 1	84 2 WB	Crawford	12/19	too steep	regraded?	dg; dt @ top slope		es-r	e	m5	L1/?		145	70	7972		12-16	14	2,756	y	y		73	Jan-87	SV was in incorrect location
166	27	64 1	85.2 MED	Crawford	12/18	GW @ s/r interface	rock backfill	dg	nc	es-r	c	m5	U2/3	19	100	60	4712		2-16	9	1,047	y	y		73	Sep-82	
167		64 1	85 2 WB	Crawford	12/17	GW @ s/r interface	rock backfill	vdb, dt @ top slope	nc	es-r	c	m5	U1/4	18	85	70	4673		13	13	1,500	y	y		73	Feb-87	
168	27	64.1	85 6 EB	Crawford	12/11	GW @ s/r interface	rock backfill	db, patchy db outside r/r; dt @ top slope	c	es-r	c	m4	M1/3	23	30	75	1767		3-7	5	218	y	y		73	Sep-82	
169	27	64 1	87.0 EB	Crawford	12/12	failed CPID, GW @ s/r interface	rock backfill	dg outside r/r; m-dt @ top	c	es-r	c	m5	E	20	75	75	4418		1-4	3	273	y	y		73	Oct-82	
170		64 1	88 5 EB	Crawford	12/14	too steep	rock backfill	dg outside r/r; dt @ top slope	c	es-r	c	m5	M3/4	16	85	70	4673		2-6	4	462	y	y		73	Jun-86	
171	27	64 1	88 7 EB	Crawford	12/13	GW @ s/r interface	rock backfill	dg outside r/r; dt @ top slope	c	es-r	c	m4	M3/4	16	105	110	9071		2-5	5	1,008	y	y		73	Sep-82	
172		64.1	89.1 EB	Crawford	12/15		rock backfill	dg outside r/r; dt @ top slope	c	es-r	c	m3	E	15	150	100	11781		10-14	12	3,491	y	y		73	Feb-87	
173	27	64 1	89 4 WB	Crawford	12/10	CMP saturated slope, noticed GW seeps @ toe	rock backfill	dg, dt @ top slope		es-r	c	m3	L3/4	21	75	95	5596		2	2	276	y	y		73	Sep-82	SV was in incorrect location
174	27	64 1	89 5 EB	Crawford	12/16	GW @ s/r interface, erosion	rock backfill	dg outside r/r; dt @ upper limit of r/r	c	es-r	c	m4	E	24	110	75	6480		2	2	320	y	y		73	Sep-82	
175	27	64 1	89 5 WB	Crawford	12/8,9	failed cpid	rock backfill	dg outside r/r; dt @ toe	c	es-r	c	m3	U3/4	18	215	100	16886		2-3	3	1,042	y	y		73	Jun-82	
176	27	64 1	89.8 WB	Crawford	12/7	GW @ s/r interface		dg, st		es-r	c	m4	E	19	60	75	3534		10-20	15	1,309	y	y		73	Sep-82	Per SV no apparent sign of failure
177	new	64 1	92, Exit 92, NW ramp	Crawford	1/6,7			dg, dt beyond toe	nc	es-r	e	m5	U1/?	13	335	110	28,942	13	5-10	8	9,290	y	y	y	72	98	
178		64 1	96 4 EB	Crawford	12/5,6	too steep		st, sg throughout slope, m-dt @ top slope	nc		c	m5	M3/4	19	65	90			25	25		y	y	n	74, R94	Dec-85	Per SV appeared to be erosion only, erosion of cpsd Per DO maint forces have placed rip rap
179	27/78	64 1	118 1 EB	Floyd	12/4	too steep	rock backfill	vdg	c		c	m2	U3/4	23	75	45	2,651		25	25		y	y	n	74 R95	Dec-85	Per DD maint forces have placed rip rap and monitor those places regularly
180	71	65	SR 65, 2 34 mi N SR 64	Gibson	3/19,20	inadequate drainage and benching GW @ s/r interface	rock backfill	m-dt	nc	es-r	e	p3	U1/?	13-16	310	200	48,695		10-28	19	22,844	y	y	n	55	Jan-86	Per DD continually active, NBL requires yearly wedges, settles 2"/yr
181	220	65 1	I-65, 2 4 mi S Clark/Scott line, Area 2 across from A-4	Clark	8/16,17	failed CPID and subsequent erosion of toe, engineering of fill, smaller area here has shoulder drain to flank	rip rap or rock backfill	dg outside r/r; dt @ toe	cne		e	m1	E	31	70	50	2,749					y	n	n	58-59	Oct-87	Per DO repaired by state forces
182	220	65 1	I-65, 2 4 mi S Clark/Scott line, Area 3 across from A-1	Clark	8/18,19	failed CPID and subsequent erosion of toe, engineering of fill, occurs within CMP flow inlet beneath emb	rock backfill	dg outside r/r, dt @ toe	pc		e	m1	E	32	330	70	18,143					y	n	n	58-59	Oct-87	Per DO repaired by state forces
183	220	65 1	I-65, 2 4 mi S Clark/Scott line, Area 4 across from A-2	Clark	8/18,19	failed CPID subsequent erosion of toe, engineering of fill, small shoulder drain runs through area	rock backfill	dg outside r/r; dt @ toe	pc		e	m1	E	32	430	70	23,640					y	n	n	58-59	Oct-87	Per DD repaired by state forces
184	58	66	SR 66, 4 6 mi W SR 70, Area 1	Spencer	8/7	sloping bedrock	rock key, bin wall, reinforced earth wall	dt	nc	es-r	c	p1	E	22	###	20	16,022	12	2-18	10	4 747	y	y	n	32	Apr-85	Per DD most slides still active, ditched 1-2 times per yr , trees and large rocks removed from road periodically
185	58	66	SR 66, 4 4 mi W SR 70, Area 2	Spencer	8/6	sloping bedrock	removal-serrated slopes	dt	nc	es-r	c	p1	L1/?	14-19	90	70	4,946		0-20	10	1,222	y	y	n	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically
186	58	66	SR 66, 2 3 mi W SR 70, Area 3	Spencer	8/4,5	sloping bedrock	rock key, binwall or reinforced earth wall	dt	nc	es-r	c	p1	L1/?	14-19	115	60	5,419		1-10	6	736	y	y	n	32	Apr-85	Per DD most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically
187	58	66	SR 66, 2.1 mi W SR 70, Area 4a	Spencer		sloping bedrock, springs present	binwall or reinforced earth wall	dt	nc	es-r	c	p1	L1/?	13-38	170	170	22,696		0-18	9	5,044	y	y	n	32	Apr-85	Per DD most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically
188	58	66	SR 66, 2.1 mi W SR 70, Area 4b	Spencer	8/3	sloping bedrock, springs present	binwall or reinforced earth wall	dt	nc	es-r	c	p1	L1/?	13-38	240	135	25,447		0-18	9	5,655	y	y	n	32	Apr-85	Per DD most slides still active, ditched 1-2 times per yr , trees and large rocks removed from road periodically
189	58	66	SR 66, 2 1 mi W SR 70, Area 4c	Spencer		sloping bedrock	binwall or reinforced earth wall	dt	nc	es-r	c	p1	L1/?	13-38	165	120	15,551		0-18	9	3,456	y	y	n	32	Apr-85	Per DO most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically
190	58	66	SR 66, 1.3 mi W SR 70, Area 5	Spencer	7/2	sloping bedrock, springs present	binwall or reinforced earth wall	vdt	nc	es-r	c	p1	L1/?	16-34	310	220	53,564	25	0-18	9	33,064	y	y	n	32	Apr-85	Per DD most slides still active, ditched 1-2 times per yr , trees and large rocks removed from road periodically
191	58	66	SR 66, 1 15 mi W SR 70, Area 6	Spencer	7/1	sloping bedrock	removal-serrated slopes	dt	nc	es-r	c	p1	L1/?	17-23	170	170	22,698		0-16	8	4 484	y	y	n	32	Apr-85	Per DD most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically
192	58	66	SR 66, 0 95 mi W SR 70, Area 7	Spencer	7/24	cleaning of vegetation, sloping bedrock, spring emerging from slope	rock key or binwall or reinforced earth wall	vdt	nc	es-r	c	p1	L1/?	15-30	440	180	62,204	25	0-6	3	38,397	y	y	n	32	Apr-85	Per DD most slides still active, ditched 1-2 times per yr , trees and large rocks removed from road periodically
193	58	66	SR 66, .80 mi W SR 70, Area 8	Spencer	7/23	sloping bedrock GW @ s/r interface	removal-serrated slopes	vdb-mt	nc	es-r	c	p1	L1/?	35-48	140	20	2,199		5-12	9	462	y	y	n	32	Apr-85	Per DD most slides still active, ditched 1-2 times per yr., trees and large rocks removed from road periodically
194	224	66	SR 66, 0 2 mi E SR 70	Spencer	7/4,5	creek @ toe	rock backfill	dg outside r/r, mt @ top of slope	c		e	p1	E	33					2-5	4		n	y	n	86	Oct-85	
195	104	66	SR 66, 0 3 mi E of SR 545	Perry	2/10-13	possibly mine subsidence, creek @ toe	rock backfill	vdg-b; vdt @ toe	nc	es-r	e	p1	E	38	360	150	42,412	20	16-20	18	20,944	y	y	y	40, 49	92	Old coal mine underneath site Per DOC reevaluation in progress Per DO slide stable until 3/97 flood, cracking currently, requires R/W to repair
196	223	66	SR 66, 6 3 mi N SR 70	Perry	1/11,12	erosion of toe?	relocating creek channel	vdt outside construction zone for remediation of LS	nc		e	m4												y	79	Sep-91	Engr Report dated 1/97 discussing various remediation techniques and costs Per DO currently being repaired by contract
197	15	66	SR 66, 2.6 S of SR 64	Crawford	1/1-5		rock backfill	dg	pc	es-r	c	m4	E	25	160	40	5,027		6-12	9	1,117	y	y	n	68	Oct-89	Per DD mostly erosion, partial repair by INDOT. Road may have been realigned through area Per SV landslides may not be same ones as described in file
198	70	70	SR 70, 0 1 mi W SR 66, Area 1	Spencer	2/16,17	creek erosion of toe	rock backfill	dg outside r/r	c	es-r	e	p1	E		30	30	707		<20	20	349	y	y	y	24, W68	Mar-84	
199	70	70	SR 70, 0.1 mi W SR 66, Area 2	Spencer	2/14,15	creek erosion of toe	rock backfill	dg outside r/r	c	es-r	e	p1	E		30	55	1,296		<20	20	640	y	y	n	24, W68	Mar-84	
200	70	70	SR 70, 0.1 mi W SR 66, Area 3	Spencer	2/18	creek erosion of toe	rock backfill	dt	nc	es-r	e	p1	L1/2		200	67	10,524		<20	20	5,197	y	y	n	24, W68	Mar-84	Per DD slide active, pushing on NE corner of endbent of STR 70-74-26A, requires ditching 2/yr
201	69	70 1	I-70, 0.1 mi E SR 243	Putnam		slope saturated by drain outlet		db, dg; mst near top, cattails @ toe	nc	es-r	c	m4	U3/4	20	180	117	16,540		20	20	8,168	y	y	n	65, R86	Mar-86	Per DD no maintenance done @ location, does not seem to be an active landslide, no immediate concern.
202		74 1	155 4 EB	Ripley	14/14	too steep, erosion of CPID	rock backfill	s-dt outside r/r to West, dg to E or r/r	c		e	o4	E	29	200	47	7050		5-30	13		y	y		62	Jul-87	
203		74 1	156.0 WB	Ripley	14/15	too steep	rock backfill	dg, sst outside r/r	c		e	o4	U3/4	30	83	40	2490		>50			y	n		62	Apr-86	
204		74 1	156 6 EB, Area 1	Ripley	14/16	too steep	rock backfill	dg outside r/r, m-dt @ top of slope	c	es	c	o3	L3/4	27	55	35	1444		20-40	30		y	y		62	Jun-85	
205		74 1	156 6 EB, Area 2	Ripley	14/16	too steep	rock backfill	dg outside r/r, m-dt @ top of slope	c	es	c	o3	L1/2	27	30	20	450		20-40	30		y	y		62	Jun-85	
206		74 1	159.7 EB	Dearborn	14/17,18	too steep	appeared rip rap was just dumped into failed area	dg, st outside r/r, sg w/in r/r; dt @ toe	cne	es-r	e	o4	M1/3	25	57	20	855		5-30	18	387	y	y		62	Jul-85	Underlain by limestone bedrock
207		74 1	160 5 WB	Dearborn	14/19	too steep	rock backfill	dg-b outside r/r, dt @ top slope	c	es-r	c	o4	E	26	200	55	8250					y	n		62	Apr-86	

ID	File	Roadway	Location	County	photo log log/pic		date of ad uction	Earliest reported date of failure	Miscellaneous Comments
208		74.1	160.8 EB	Dearbom	14/20	eros	62	Jun-85	Mostly erosion features, small sump induced by severe erosion.
209		74.1	168.9 EB	Dearbom	14/21,22		1, W95	May-86	Per SV couldn't see failure in thick brush, fresh cracks in road and parapet
210		74.1	171.2 EB(171.1 EB)	Dearbom	14/23	too s	60	Apr-86	
211	96	111	SR 111, junct w/ Mt. Tabor Rd, near I-265	Floyd	8/24			Apr-93	Per DO repaired with new SR 111 road reconstruction.
212	227	145	SR 145, 0.3 mi S of Bristow	Perry	2/5	GW drain	67	77	1991 proposed realignment of road, inclinometer data also. Per DO large active slide, road wedged periodically.
213	97	145	SR 145, 4.6 mi N I-64	Dubois	1/23	too s slop	68, 87	Jul-93	Slide is 10 yrs old Per DO small slide caused by creek, not a priority
214	226	145	SR 145, 6.9 mi S SR 56, Area 1	Orange	6/8	too s	67	Jan-90	Per DO repaired by subdistrict 1993. Per SV no apparent sign of failure.
215	226	145	SR 145, 6.9 mi S SR 56, Area 2	Orange	6/9	too s	67	Jan-90	Per DO repaired by subdistrict 1993. Per SV no apparent sign of failure.
216	51	150	US 150, 0.5mi E of Natchez	Martin	5/24	GW	4, W56	Feb-87	Per DO slide has not moved in 5 yrs.
217	45	168	SR 168, 5.3 mi W of SR 57, Area 1	Gibson	3/17,18		58	Feb-82	Per DO no new movement
218	45	168	SR 168, 5.3 mi W of SR 57, Area 2	Gibson	3/17,18		58	Feb-82	Per DO no new movement.
219	11	225	SR 225, 1.5-1.7 mi E of SR 43, Area 1	Tippecanoe	7/7	eros	'2, R95	Mar-86	Per DO didn't find where problem was. Per SV standing water at toe of slope and corrected w/ rip rap.
220	11	225	SR 225, 1.5-1.7 mi E of SR 43, Area 2	Tippecanoe	7/7	eros	'2, R95	Mar-86	Per DO didn't find where problem was. Per SV standing water at toe of slope and corrected w/ rip rap.
221	11	225	SR 225, 1.5-1.7 mi E of SR 43, Area 3	Tippecanoe	7/8,9	eros	'2, R95	Mar-86	Per DO didn't find where problem was. Per SV standing water at toe of slope and corrected w/ rip rap
222	100	231	US 231, 3.1 mi S. SR 54	Greene	4/7-11	GW	46, 48	Jul-79	Sinkhole nearby?? Per DO does not endanger 231, but is at R/W line, no movements in last year.
223	16	231	US 231 4.5 S of US 50, Area 1a	Martin	4/12	ditch	0, W75	May-90	Per DO slide is off R/W with toe under US 231shoulder;continually moving, cut slope Bedrock 12-22' @ toe of slide. May have been caused by ditch cutting
224	16	231	US 231 4.5 S of US 50, Area 1b	Martin	4/12	ditch	0, W75	May-90	Per DO slide is off R/W with toe under US 231shoulder;continually moving, cut slope. Bedrock 12-22' @ toe of slide
225	16	231	US 231 4.5 S of US 50, Area 1c	Martin	4/12	ditch	0, W75	May-90	Per DO slide is off R/W with toe under US 231shoulder;continually moving, cut slope Bedrock 12-22' @ toe of slide
226	16	231	US 231 4 5 S of US 50, Area 2	Martin		ditch	0, W75	May-90	Per DO slide is off R/W with toe under US 231shoulder;continually moving, cut slope. Bedrock 12-22' @ toe of slide.
227	114	250	SR 250, 0.6 mi W of SR 156, Area 1	Switzerland	11/15	cree prob	68	Jan-98	Per DO subdistrict forces wedge, level and monitor. Unsure if slide extends to creek. Per SV fresh asphalt segments through failed area
228	114	250	SR 250, 0.6 mi W of SR 156, Area 2	Switzerland	11/16	cree prob	68	Jan-98	Per DO subdistrict forces wedge, level and monitor. Unsure if slide extends to creek. Per SV fresh asphalt segments through failed area
229	114	250	SR 250, 0.6 mi W of SR 156, Area 3	Switzerland	11/17	cree prob	68	Jan-98	Per DO subdistrict forces wedge, level and monitor. Unsure if slide extends to creek. Per SV fresh asphalt segments through failed area
230	114	250	SR 250, 0.6 mi W of SR 156, Area 4	Switzerland	11/18	cree prob	68	Jan-98	Per DO subdistrict forces wedge, level and monitor. Unsure if slide extends to creek. Per SV fresh asphalt segments through failed area
231	230	262	SR 262, 3.5 mi S US 50	Dearbom	11/13	engi cree inter	60	Apr-90	Per DO subdistrict repaired, wedged, leveled, and monitors
232	52/66	262	SR 262 N of Milton over Laughery Creek, Area 1	Dearbom	11/11,12	GW slopi	76	Mar-85	Per DO monitored
233	52/66	262	SR 262 N of Milton over Laughery Creek, Area 2	Dearbom	11/11,12	GW slopi	76	Mar-85	Per DO monitored
234	52/66	262	SR 262 N of Milton over Laughery Creek, Area 3	Dearbom	11/11,12	GW slopi	76	Mar-85	Per DO monitored.
235	35	275	I-275, 0.6 mi W of state line (N crossing of St. line)	Dearbom	10/13	poss and	'4, R93	Feb-87	Failure while rehab work performed on Structure No. 275-2-5641. Per DO slide repaired-monitored by subdistrict
236	47	350	SR 350, 6.7 mi W of US 50, Area 1 across from A-2	Dearbom	11/5	CMF	56	Nov-80	Per DO being monitored by subdistrict. Per SV no apparent sign of failure, also 2 other areas of slides near here.
237	47	350	SR 350, 6.7 mi W of US 50, Area 2 across from A-1	Dearbom	11/6	CMF	56	Nov-80	Per DO being monitored by subdistrict. Per SV 2 other areas of slides near here.
238	101	443	SR 443, 0.5 mi N SR 43	Tippecanoe			76	Jun-93	Per DO, no slide has been noticed since correction.
239	102	450	SR 450, 2.0 mi S. SR 158, Area 1	Lawrence		too s	76	Apr-83	Per DO repaired 1995.
240	102	450	SR 450, 2.0 mi S. SR 158, Area 2	Lawrence	5/20	too s	76	Apr-83	Per DO repaired 1995.
241	102	450	SR 450, 2.0 mi S. SR 158, Area 3	Lawrence	5/20	too s	76	Apr-83	Per DO repaired 1995.
242	102	450	SR 450, 2.0 mi S. SR 158, Area 4	Lawrence		too s	76	Apr-83	Per DO repaired 1995.
243	102	450	SR 450, 2.0 mi S. SR 158, Area 5	Lawrence	6/7	too s	76	Apr-83	Per DO repaired 1995.
244	102	450	SR 450, 2.0 mi S. SR 158, Area 6	Lawrence	6/7	too s	76	Apr-83	Per DO repaired 1995.
245	17	450	SR 450, 8.61 mi E of US 50, NE area	Martin	4/14	engi	76	79	Original report in '79 addressed LS's in area.'94, another FI required due to movement. Recompacted clay over siltstone
246	17	450	SR 450, 8.61 mi E of US 50, NW area	Martin	4/16	engi	76	79	Original report in '79 addressed LS's in area. Per DO slide in fill section,continually moving, high priority. Recompacted clay over siltstone. FC 12/94 water coming out of ground @ toe in 2 places were culverts blocked.
247	17	450	SR 450, 8.61 mi E of US 50, SW area	Martin		engi	76	79	Original report in '79 addressed LS's in area.'94, another FI required due to movement. Per DO slide in fill section,continually moving, high priority Recompacted clay over siltstone.
248	17	450	SR 450, 8.9 mi E of US 50, Area 1	Martin	5/23		76	Feb-90	
249	17	450	SR 450, 8.9 mi E of US 50, Area 2	Martin			76	Feb-90	

LANDSLIDE INVENTORY

ID	File	Roadway	Location	County	photo log log/pic	Probable Cause	Remedial Method	Vegetation	Correction status	Landslide type	Slope type	Bedrock type	GEOMETRIC INFORMATION: Failure position	Slope (°)	W ft	L ft	plan area ft²	D ft	OB (range) ft	OB (avg) ft	volume yds³	DATA AVAILABLE: Field sketch	Borelogs	Slope inc.	Initial date of road construction	Earliest reported date of failure	Miscellaneous Comments
208		74.1	160 8 E8	Dearborn	14/20	erosion of CPIO at flanks of slide	rock backfill	dg, mb, sst outside r/r, dt @ top	c		c	o4	E	27	80	45	2700		7-30	19		y	y		62	Jun-85	Mostly erosion features, small sump induced by severe erosion
209		74.1	168 9 E8	Dearborn	14/21,22			vdb		es	e	o2	M2/3	28	45	25	844		10-25	18		y	y		61, W95	May-86	Per SV couldn't see failure in thick brush, fresh cracks in road and parapet
210		74.1	171 2 E8(171.1 E8)	Dearborn	14/23	too steep	rock backfill	db, m-dt outside r/r	c		e	o2	E	30	105	70	5513		5-45	25		y	y		60	Apr-86	
211	96	111	SR 111, junct w/ Mt Tabor Rd, near I-265	Floyd	8/24		rock backfill	dg (lawn) outside r/r	c		c	m1	E	33	140	30	3,299					n	y	n		Apr-93	Per DO repaired with new SR 111 road reconstruction.
212	227	145	SR 145, 0 3 mi S of Bristow	Perry	2/5	GW @ s/r interface, inadequate drainage	rock backfill	vdt	nc	es-r	e/c	m6		12-15	###	217	#####	12	11-22	17	62,113	y	y	y	67	77	1991 proposed realignment of road, inclinometer data also Per DO large active slide, road wedged periodically
213	97	145	SR 145, 4 6 mi N I-64	Dubois	1/23	too steep, removal of vegetation, sloping bedrock	rock backfill	dt	nc	es-r	c	m6	L1/?	13-25	107	140	11,765	10	10	10	2,905	y	y	n	68, 87	Jul-93	Slide is 10 yrs old. Per DO small slide caused by creek, not a priority
214	226	145	SR 145, 6 9 mi S SR 56, Area 1	Orange	6/8	too steep	rock backfill w/ B borrow (on top?) Regraded?	dg	c		c	m6	E	20	90	65	4,595		<20	20		y	n	n	67	Jan-90	Per DO repaired by subdistrict 1993 Per SV no apparent sign of failure
215	226	145	SR 145, 6.9 mi S SR 56, Area 2	Orange	6/9	too steep	rock backfill w/ B borrow (on top?). Regraded?	dg	c		c	m6	E	15	130	75	7,658		<20	20		y	n	n	67	Jan-90	Per DO repaired by subdistrict 1993 Per SV no apparent sign of failure.
216	51	150	US 150, 0.5mi E of Natchez	Martin	5/24	GW @ s/r interface, creek @ toe	rock backfill	vdt	nc	es-r	e	p1	E	23	75	38	2,238		2-20	13	696	y	y	n	24, W56	Feb-87	Per DO slide has not moved in 5 yrs
217	45	168	SR 168, 5.3 mi W of SR 57, Area 1	Gibson	3/17,18		rock backfill	vdg-b outside r/r; sb w/in LS	cne	es-r	c	p3	E	23	150	60	7,069	10	10	10	1,745	y	y	n	58	Feb-82	Per DO no new movement
218	45	168	SR 168, 5 3 mi W of SR 57, Area 2	Gibson	3/17,18			dg, b	nc	es-r	c	p3	L1/4	23	100	15	1,178		10	10	291	y	y	n	58	Feb-82	Per DO no new movement.
219	11	225	SR 225, 1.5-1 7 mi E of SR 43, Area 1	Tippecanoe	7/7	erosion of toe by creek	rip rap	mg-b w/in r/r; vdb-dt outside r/r	c	es	e	D	E	35	205	40	6,440		150	150		y	y	n	72, R95	Mar-86	Per DO didn't find where problem was Per SV standing water at toe of slope and corrected w/ rip rap
220	11	225	SR 225, 1 5-1 7 mi E of SR 43, Area 2	Tippecanoe	7/7	erosion of toe by creek	rip rap	mg-b w/in r/r; vdb-dt outside r/r	pc	es	e	D	E	35	285	55	12,311		150	150		y	y	n	72, R95	Mar-86	Per DO didn't find where problem was Per SV standing water at toe of slope and corrected w/ rip rap
221	11	225	SR 225, 1 5-1.7 mi E of SR 43, Area 3	Tippecanoe	7/8,9	erosion of toe by creek		vdb, vdt	nc	es	e	D	E	35	185	50	7,265		150	150		y	y	n	72, R95	Mar-86	Per DO didn't find where problem was Per SV standing water at toe of slope and corrected w/ rip rap
222	100	231	US 231, 3 1 mi S SR 54	Greene	4/7-11	GW @ s/r interface	rock backfill	m-db w/in LS; dt outside LS, dg (lawn) @ top beyond scarp	nc	es-r	c	m6	E	11-25	163	125	16,002	17	5-17	11	6,717	y	y	n	46, 48	Jul-79	Sinkhole nearby?? Per DO does not endanger 231, but is at R/W line, no movements in last year
223	16	231	US 231 4,5 S of US 50, Area 1a	Martin	4/12	ditch maintenance, too steep	rock backfill w/and w/o B-borrow	dg (pasture). m-dt @ toe along fence row	nc		c	p1	E	13	230	110	19,871		>15	15		y	y	n	30, W75	May-90	Per DO slide is off R/W with toe under US 231shoulder;continually moving, cut slope Bedrock 12-22' @ toe of slide May have been caused by ditch cutting
224	16	231	US 231 4 5 S of US 50, Area 1b	Martin	4/12	ditch maintenance, too steep	rock backfill w/and w/o B-borrow	dg (pasture). m-dt @ toe along fence row	nc		c	p1	L1/4	20	130	20	2,042		>15	15		y	y	n	30, W75	May-90	Per DO slide is off R/W with toe under US 231shoulder;continually moving, cut slope Bedrock 12-22' @ toe of slide
225	16	231	US 231 4 5 S of US 50, Area 1c	Martin	4/12	ditch maintenance, too steep	rock backfill w/and w/o B-borrow	dg (pasture); m-dt @ toe along fence row	nc		c	p1	L1/2		25	15	295		>15	15		y	y	n	30, W75	May-90	Per DO slide is off R/W with toe under US 231shoulder;continually moving, cut slope Bedrock 12-22' @ toe of slide.
226	16	231	US 231 4 5 S of US 50, Area 2	Martin		ditch maintenance, too steep	rock backfill w/and w/o B-borrow	mt	nc		c	p1	L3/4		90	20	1,414		>15	15		y	y	n	30, W75	May-90	Per DO slide is off R/W with toe under US 231shoulder;continually moving, cut slope. Bedrock 12-22' @ toe of slide
227	114	250	SR 250, 0 6 mi W of SR 156, Area 1	Switzerland	11/15	creek at toe (not mentioned as probable cause)	rip rap or rock backfill	dg db, m-dt	cne		e	o2		25	300	88	20,735					n	n	n	68	Jan-98	Per DO subdistrict forces wedge, level and monitor Unsure if slide extends to creek Per SV fresh asphalt segments through failed area
228	114	250	SR 250, 0 6 mi W of SR 156, Area 2	Switzerland	11/16	creek at toe (not mentioned as probable cause)		d-vdt	nc		e	o2		22	125	90	8,836					n	n	n	68	Jan-98	Per DO subdistrict forces wedge, level and monitor. Unsure if slide extends to creek Per SV fresh asphalt segments through failed area
229	114	250	SR 250, 0 6 mi W of SR 156, Area 3	Switzerland	11/17	creek at toe (not mentioned as probable cause)		m-dt	nc		e	o2		22	515	60	24 269					n	n	n	68	Jan-98	Per DO subdistrict forces wedge, level and monitor. Unsure if slide extends to creek Per SV fresh asphalt segments through failed area
230	114	250	SR 250, 0 6 mi W of SR 156, Area 4	Switzerland	11/18	creek at toe (not mentioned as probable cause)		vdb, dt @ toe along creek	nc		e	o2		13	426	110	36,804					n	n	n	68	Jan-98	Per DO subdistrict forces wedge, level and monitor Unsure if slide extends to creek. Per SV fresh asphalt segments through failed area
231	230	262	SR 262, 3.5 mi S US 50	Dearborn	11/13	engineering of fill, sloping bedrock, creek erosion of toe, GW @ soil/rock interface	rock backfill	db-mt outside r/r	c	es-r	e	o2	E	30	260	60	16,336		12	12	4,840	y	y	n	60	Apr-90	Per DO subdistrict repaired, wedged, leveled, and monitors
232	52/66	262	SR 262 N of Milton over Laughery Creek, Area 1	Dearborn	11/11,12	GW @ soil/rock interface, too steep, sloping bedrock	rock backfill	vdg, vdb, d-st cattails @ toe in ditch	nc	es-r	c	o2	M1/4	27	50	15	589		6-10	8	116	y	y	n	76	Mar-85	Per DO monitored
233	52/66	262	SR 262 N of Milton over Laughery Creek, Area 2	Dearborn	11/11,12	GW @ soil/rock interface, too steep, sloping bedrock	rock backfill	vdg, vdb, d-st cattails @ toe in ditch	nc	es-r	c	o2	M1/4	27	50	20	785		6-10	8	155	y	y	n	76	Mar-85	Per DO monitored
234	52/66	262	SR 262 N of Milton over Laughery Creek Area 3	Dearborn	11/11,12	GW @ soil/rock interface, too steep sloping bedrock	rock backfill	vdg, vdb, d-st cattails @ toe in ditch	nc	es-r	c	o2	U3/4	27	420	90	29,688	10	6-10	8	7,330	y	y	n	76	Mar-85	Per DO monitored
235	35	275	I-275, 0 6 mi W of state line (N crossing of St. line)	Dearborn	10/13	possibly due to drainage from median and roadway which saturated slope	rock backfill	dg-db outside r/r	c	es	e	o2	E	25	39	40	1,228	6	100	100	182	y	y	y	74, R93	Feb-87	Failure while rehab work performed on Structure No. 275-2-5641 Per DO slide repaired-monitored by subdistrict
236	47	350	SR 350, 6 7 mi W of US 50, Area 1 across from A-2	Dearborn	11/5	CMP inlet within failure	regraded?	dg			e	o3	L1/4	26	60	45	2,121					y	n	n	56	Nov-80	Per DO being monitored by subdistrict Per SV no apparent sign of failure. also 2 other areas of slides near here
237	47	350	SR 350, 6 7 mi W of US 50, Area 2 across from A-1	Dearborn	11/6	CMP outlet within failure	rip rap or rock backfill, still failing	dg	cne		e	o3	E	25	103	87	7,038					y	n	n	56	Nov-80	Per DO being monitored by subdistrict Per SV 2 other areas of slides near here
238	101	443	SR 443, 0.5 mi N SR 43	Tippecanoe			gabion wall		c	es	c	Dm	E	36	33	64	1,659		200-250	225		y	n	n	76	Jun-93	Per DO, no slide has been noticed since correction.
239	102	450	SR 450, 2.0 mi S SR 158, Area 1	Lawrence		too steep, engineering of fill	B borrow backfill and flatten slope	vdg	c	es	e	m2	U1/2	19	90	30	2,121		40	40		y	y	n	76	Apr-83	Per DO repaired 1995
240	102	450	SR 450, 2.0 mi S SR 158, Area 2	Lawrence	5/20	too steep, engineering of fill	B borrow backfill and flatten slope	vdg	c	es	e	m2	U3/4	19	575	70	31,612	10	40	40	7,806	y	y	n	76	Apr-83	Per DO repaired 1995.
241	102	450	SR 450, 2 0 mi S. SR 158, Area 3	Lawrence	5/20	too steep, engineering of fill	B borrow backfill and flatten slope	vdg	c	es	e	m2	U3/4	19	490	70	26,939	13	40	40	8,647	y	y	n	76	Apr-83	Per DO repaired 1995
242	102	450	SR 450, 2 0 mi S. SR 158, Area 4	Lawrence		too steep, engineering of fill	B borrow backfill and flatten slope	vdg	c	es	e	m2	U1/4	19	80	30	1,885	13	40	40	605	y	y	n	76	Apr-83	Per DO repaired 1995.
243	102	450	SR 450, 2 0 mi S SR 158, Area 5	Lawrence	6/7	too steep, engineering of fill	B borrow backfill and flatten slope	vdg	c	es	e	m2	U1/4	19	90	35	2,474	5	40	40	305	y	y	n	76	Apr-83	Per DO repaired 1995.
244	102	450	SR 450, 2.0 mi S. SR 158, Area 6	Lawrence	6/7	too steep, engineering of fill	B borrow backfill and flatten slope	vdg	c	es	e	m2	U1/2	19	160	60	7,540	8	40	40	1,489	y	y	n	76	Apr-83	Per DO repaired 1995
245	17	450	SR 450, 8 61 mi E of US 50, NE area	Martin	4/14	engineering of fill	rock backfill or B-borrow	vdg, sst	c	es-r	e	m4	E	26	160	100	12,566	15	8-57	33	4,654	y	y	n	76	79	Original report in '79 addressed LS's in area '94, another FI required due to movement Recompacted clay over siltstone
246	17	450	SR 450, 8 61 mi E of US 50, NW area	Martin	4/16	engineering of fill	rock backfill or B-borrow	vdg-b, st	nc	es-r	e	m4	E	26	320	145	36,442		10-65	38	33,743	y	y	n	76	79	Original report in '79 addressed LS's in area Per DO slide in fill section,continually moving, high priority Recompacted clay over siltstone FC 12/94 water coming out of ground @ toe in 2 places were culverts blocked
247	17	450	SR 450, 8 61 mi E of US 50, SW area	Martin		engineering of fill	rock backfill or B-borrow	vdg, st	nc	es-r	e	m4	E	29	330	110	28,510	23	12-65	39	16,191	y	y	n	76	79	Original report in '79 addressed LS's in area '94, another FI required due to movement. Per DO slide in fill section,continually moving, high priority Recompacted clay over siltstone
248	17	450	SR 450, 8.9 mi E of US 50, Area 1	Martin	5/23		rock backfill or B-borrow	vdg, st	nc		c	m5	E	25	350	75	20,617		<20	20		y	n	n	76	Feb-90	
249	17	450	SR 450, 8 9 mi E of US 50, Area 2	Martin			rock backfill or B-borrow	vdg, st	nc		c	m5	E		50	40	1,571		<20	20		y	n	n	76	Feb-90	

ID	File	Roadway	Location	County	photo log log/pic		l date of oad truction	Earliest reported date of failure	Miscellaneous Comments
250	17	450	SR 450, 8.9 mi E of US 50, Area 3	Martin			76	Feb-90	
251	17	450	SR 450, 8.9 mi E of US 50, Area 4	Martin			76	Feb-90	
252	new	545	SR 545, 1.4 mi N SR 164	Dubois	6/10,11		83		Failure in extremely weathered shale
253	5	545	SR 545, 5.5 mi N of SR 164	Dubois	4/21-26	GW	83	Jun-90	failure in 1990 (per prop owner, '87), again in1994 Per DO slide active, corrective measures taken by INDOT, has moved off R/W and broken sewer.
254	56	545	SR 545, 8.5 mi N of SR 66	Spencer	2/19, 7/6	GW	39, 85	Jul-86	Per DO slide is small and stable, not a priority Failure within bedrock or @ s/r interface
255	62	545	SR 545, Area 1	Dubois	6/13	GW	83	Jun-84	
256	62	545	SR 545, Area 2	Dubois	6/14	GW	83	Jun-84	
257	62	545	SR 545, Area 3a	Dubois	6/12	GW	83	Jun-84	
258	62	545	SR 545, Area 3b	Dubois	6/12	GW	83	Jun-84	
259	62	545	SR 545, Area 3c	Dubois	6/12	GW	83	Jun-84	
260	62	545	SR 545, Area 3d	Dubois	6/12	GW	83	Jun-84	
261	62	545	SR 545, Area 4	Dubois	6/15-17	brok	83	Jun-84	
262	28		Clark State Forest Rd; N of Henryville	Clark	8/15			Oct-82	Scarp near road, drilled pier wall has prevented slide regression into road. Per DO repaired. Bedrock Locust Point and Cardwood FM of Borden group
263	76		CR 600, over I-64 @ 35.9 mi mark, A1	Warrick	7/18	too	72	Jan-85	Remediated fall 1997. Per SV no apparent sign of failure.
264	76		CR 600, over I-64 @ 35.9 mi mark, A2a	Warrick	7/19	too	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure.
265	76		CR 600, over I-64 @ 35.9 mi mark, A2b	Warrick	7/19	too	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure.
266	76		CR 600, over I-64 @ 35.9 mi mark, A3a	Warrick	7/22	too	72	Jan-85	Remediated fall 1997. Per SV no apparent sign of failure
267	76		CR 600, over I-64 @ 35.9 mi mark, A3b	Warrick	7/22	too	72	Jan-85	Remediated fall 1997. Per SV no apparent sign of failure.
268	76		CR 600, over I-64 @ 35.9 mi mark, A3c	Warrick	7/22	too	72	Jan-85	Remediated fall 1997. Per SV no apparent sign of failure.
269	76		CR 600, over I-64 @ 35.9 mi mark, A4a	Warrick	7/21	too	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure
270	76		CR 600, over I-64 @ 35.9 mi mark, A4b	Warrick	7/21	too	72	Jan-85	Remediated fall 1997. Per SV no apparent sign of failure.
271	76		CR 600, over I-64 @ 35.9 mi mark, A4c	Warrick	7/20	faile	72	Jan-85	Remediated fall 1997. Per SV no apparent sign of failure.
272	61		CR Sec 2-1, near I-64 59.9 mi mark, Area 1	Spencer	6/18	eros	72	Jan-85	Per DO repaired by INDOT in '88 and holding.
273	61		CR Sec 2-1, near I-64 59.9 mi mark, Area 2	Spencer	6/18	eros	72	Jan-85	Per DO repaired by INDOT in '88 and holding.
274	61		CR Sec 2-1, near I-64 59.9 mi mark, Area 3	Spencer	6/18	sco	72	Jan-85	Per DO repaired by INDOT in '88 and holding.
275	63		French Ridge Road, Area 1	Perry	6/20			Feb-86	
276	63		French Ridge Road, Area 2	Perry	6/21,22			Feb-86	
277	63		French Ridge Road, Area 3	Perry	6/23			Feb-86	
278	63		French Ridge Road, Area 4	Perry	6/24,25			Feb-86	
279	13		Bristow-St. Meinrad Rd from CR 42 to SR 145, Area 1	Perry	6/19			87	
280	13		Bristow-St. Meinrad Rd from CR 42 to SR 145, Area 2	Perry				78	Reported to have originally occurred in '78; Near a former coal mine entrance. Could not locate during SV.
281	65		Bedford Unit Access Rd, 0.1 mi N SR 158 in Bedford	Lawrence	6/6			Apr-88	Per DO not active.
282	94		CR 3 (German Ridge Rd.) N SR 66	Perry	7/3			Nov-93	Geotech invest performed 6/95.
283	85/215		Mt. Vernon Rd, in front of house, S of SR 62	Vanderburgh	3/14-16			May-86	Per DO active and a priority.
284	64		State St, 0.1 mi W I-265 in New Albany	Floyd	8/23	cha con		Oct-83	Per DO slide repaired by contract.

LANDSLIDE INVENTORY

ID	File	Roadway	Location	County	photo log log/pic	Probable Cause	Remedial Method	Vegetation	Correction status	Landslide type	Slope type	Bedrock type	Failure position	GEOMETRIC INFORMATION Slope	W	L	plan area	O	OB (range)	OB (avg)	volume	DATA AVAILABLE Field sketch	Borelogs	Slope inc.	Initial date of road construction	Earliest reported date of failure	Miscellaneous Comments
														(°)	ft	ft	ft²	ft	ft	ft	yds³						
250	17	450	SR 450, 8.9 mi E of US 50, Area 3	Martin			rock backfill or B-borrow	vdg, st	nc		c	m5	E		290	40	9,111		<20	20		y	n	n	76	Feb-90	
251	17	450	SR 450, 8.9 mi E of US 50, Area 4	Martin			rock backfill or B-borrow	vdg, st	nc		c	m5	E		40	35	1,100		<20	20		y	n	n	76	Feb-90	
252	new	545	SR 545, 1.4 mi N SR 164	Dubois	6/10,11			s-mg	nc		c	p1	L1/3	21	115	47	4,245	20	20	20	2,096	y	n	n	83		Failure in extremely weathered shale
253	5	545	SR 545, 5.5 mi N of SR 164	Dubois	4/21-26	GW @ s/r interface	rock backfill	m-dg (pasture)	nc	es-r	c	m6	E	15	230	170	30,709	23	1-22	11	17,440	y	y	n	83	Jun-90	failure in 1990 (per prop owner, '87), again in1994 Per DO slide active, corrective measures taken by INDOT, has moved off R/W and broken sewer.
254	56	545	SR 545, 8.5 mi N of SR 66	Spencer	2/19, 7/6	GW @ s/r interface	rock backfill	mt, dg	nc	es-r	c	p1	E	29	75	65	3,829		3-12	8	709	y	y	n	39, 85	Jul-86	Per DO slide is small and stable, not a priority. Failure within bedrock or @ s/r interface
255	62	545	SR 545, Area 1	Dubois	6/13	GW @ s/r interface	rock backfill	db-t outside r/r	c	es-r	c	p1	L1/?	32	180	80	11,310	5	<5	5	1,396	y	n	n	83	Jun-84	
256	62	545	SR 545, Area 2	Dubois	6/14	GW @ s/r interface	rock backfill	db-t outside r/r	c	es-r	c	p1	L1/?	33	65	50	2,553	5	<5	5	315	y	n	n	83	Jun-84	
257	62	545	SR 545, Area 3a	Dubois	6/12	GW @ s/r interface	rock backfill	vdg-b, dt @ top of slope	nc	es-r	c	p1	E	17	120	80	7,540	5	<5	5	931	y	n	n	83	Jun-84	
258	62	545	SR 545, Area 3b	Dubois	6/12	GW @ s/r interface	rock backfill	vdg-b, dt @ top of slope	nc	es-r	c	p1	E	17	45	50	1,767	5	<5	5	218	y	n	n	83	Jun-84	
259	62	545	SR 545, Area 3c	Dubois	6/12	GW @ s/r interface	rock backfill	vdg-b, dt @ top of slope	nc	es-r	c	p1	E	22	90	60	4,241	5	<5	5	524	y	n	n	83	Jun-84	
260	62	545	SR 545, Area 3d	Dubois	6/12	GW @ s/r interface	rock backfill	vdg-b, dt @ top of slope	nc	es-r	c	p1	E	22	110	70	6,048	5	<5	5	747	y	n	n	83	Jun-84	
261	62	545	SR 545, Area 4	Dubois	6/15-17	broken waterline, abandoned cistern	rock backfill	sst w/in r/r; dt to flank of r/r, dg (lawn) on top of slope	c	es-r	c	p1	E	21	180	65	9,189	5	<5	5	1,134	y	n	n	83	Jun-84	
262	28		Clark State Forest Rd, N of Henryville	Clark	8/15		drilled pier wall	dt,st w/in top half of LS, dt w/in bottom half of LS	c	es-r	c	m1	U1/?	21	280	460	101,159					y	n	n		Oct-82	Scarp near road, drilled pier wall has prevented slide regression into road Per DO repaired Bedrock Locust Point and Cardwood FM of Borden group
263	76		CR 600, over I-64 @ 35.9 mi mark, A1	Warrick	7/18	too steep	rock backfill recommended Regraded?	dg cornfield at base of slope	c		e	p2	E	20	370	45	13,077					y	n	n	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure
264	76		CR 600, over I-64 @ 35.9 mi mark, A2a	Warrick	7/19	too steep	rock backfill recommended Regraded?	dg cornfield at base of slope	c		e	p2	L3/4	19	95	35	2,611					y	n	n	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure.
265	76		CR 600, over I-64 @ 35.9 mi mark, A2b	Warrick	7/19	too steep	rock backfill recommended Regraded?	dg, cornfield at base of slope	c		e	p2	E	19	90	45	3,181					y	n	n	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure
266	76		CR 600, over I-64 @ 35.9 mi mark, A3a	Warrick	7/22	too steep	rock backfill recommended Regraded?	dg	c		e	p2	E	19	260	65	13,273					y	n	n	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure
267	76		CR 600, over I-64 @ 35.9 mi mark, A3b	Warrick	7/22	too steep	rock backfill recommended Regraded?	dg	c		e	p2	E	19	75	45	2,651					y	n	n	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure.
268	76		CR 600, over I-64 @ 35.9 mi mark, A3c	Warrick	7/22	too steep	rock backfill recommended. Regraded?	dg	c		e	p2	U1/2	19	60	25	1,178					y	n	n	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure.
269	76		CR 600, over I-64 @ 35.9 mi mark, A4a	Warrick	7/21	too steep	rock backfill recommended. Regraded?	dg cornfield at base of slope	c		e	p2	E	20	60	75	3,534					y	n	n	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure
270	76		CR 600, over I-64 @ 35.9 mi mark, A4b	Warrick	7/21	too steep	rock backfill recommended Regraded?	dg; cornfield at base of slope	c		e	p2	E	20	80	60	3,770					y	n	n	72	Jan-85	Remediated fall 1997 Per SV no apparent sign of failure.
271	76		CR 600, over I-64 @ 35.9 mi mark, A4c	Warrick	7/20	failed CPID	rock backfill recommended Regraded?	dg	c		e	p2	E	20	175	50	6,872					y	n	n	72	Jan-85	Remediated fall 1997. Per SV no apparent sign of failure.
272	61		CR Sec 2-1, near I-64 59.9 mi mark, Area 1	Spencer	6/18	erosion of ditch @ toe	rock backfill	vdb, mst outside r/r; mg-sst w/in r/r	c		e	p1	E	27	69	100	5,419		<50	50		y	n	n	72	Jan-85	Per DO repaired by INDOT in '88 and holding
273	61		CR Sec 2-1, near I-64 59.9 mi mark, Area 2	Spencer	6/18	erosion of ditch @ toe	rock backfill	vdb, mst outside r/r; mg-sst w/in r/r	c		e	p1	L3/4	27	71	42	2,342		<50	50		y	n	n	72	Jan-85	Per DO repaired by INDOT in '88 and holding
274	61		CR Sec 2-1, near I-64 59.9 mi mark, Area 3	Spencer	6/18	scour from pipe outlet within failure	rock backfill	vdb, mst outside r/r; mg-sst w/in r/r	c		e	p1	L1/3	27	25	21	412		<50	50		y	n	n	72	Jan-85	Per DO repaired by INDOT in '88 and holding.
275	63		French Ridge Road, Area 1	Perry	6/20		rock backfill	db outside r/r; dt @ top slope	c		c	m6	L1/?	22	138	48	5,202	16	12-18	15	2,055	n	n	n		Feb-86	
276	63		French Ridge Road, Area 2	Perry	6/21,22			vdst, vdb w/in LS, vdt outside LS	nc		c	m6	L1/?	14	130	46	4,697	17	12-20	16	1,971	n	n	n		Feb-86	
277	63		French Ridge Road, Area 3	Perry	6/23			vdt	nc		e	p1		19-25	120	98	9,236	17	14-21	18	3,877	n	n	n		Feb-86	
278	63		French Ridge Road, Area 4	Perry	6/24,25			vdt	nc		e	p1		15-36	160	57	7,163	20	20-30	25	3,537	n	n	n		Feb-86	
279	13		Bristow-St. Meinrad Rd from CR 42 to SR 145, Area 1	Perry	6/19		rock backfill	dg outside r/r; dt @ top of slope	c	es-r	c	p1	E	32	40	25	785					y	y	n		87	
280	13		Bristow-St. Meinrad Rd from CR 42 to SR 145, Area 2	Perry			rock backfill		csu	es-r	e	p1	E	22	220	130	22,462	20	5-20	8	11,093	y	y	n		78	Reported to have originally occurred in '78. Near a former coal mine entrance. Could not locate during SV
281	65		Bedford Unit Access Rd, 0.1 mi N SR 158 in Bedford	Lawrence	6/6		rock backfill	vdb-s-dt	nc	es	e	m3	U1/2	25	30	25	589		<50	50		y	n	n		Apr-88	Per DO not active
282	94		CR 3 (German Ridge Rd.) N SR 66	Perry	7/3			d-vdt	nc	es-r	c	m6	L1/?		390	225	68,919	14	5-14	10	23,824	y	y	n		Nov-93	Geotech invest performed 6/95
283	85/215		Mt. Vernon Rd, in front of house, S of SR 62	Vanderburgh	3/14-16			vdg, b	nc		c	p3		27	203	59	9,407					n	n	n		May-86	Per DO active and a priority.
284	64		State St, 0.1 mi W I-265 in New Albany	Floyd	8/23	change in drainage conditions due to construction of apartment complex	retaining wall, report recommended rock backfill	vdb, vdg, m-dt patchy over area	c	es-r	c	m1	E	39	170	90	12,017	15	3-15	9	4,451	y	y	n		Oct-83	Per DO slide repaired by contract

APPENDIX C

LANDSLIDE CLASSIFICATION INVENTORY

ID	Shoulder to Scarp Distance (ft)	Slope Type	Varnes Classification	Depth of OB/FS (ft)	LANDSLIDE CLASSIFICATION		Landslide Classification Break-down											
					Earth Slump on Bedrock	Earth Slump	Type 1	Type 1b	Type 2	Type 3	Type 4	Type 5	Type 5b	Type 6	Type 7	Type 8	Type 9	unknown
1	10	e	es-r	32	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
2	225	e	es-r	20	Type 2		0	0	1	0	0	0	0	0	0	0	0	0
3	65	e	es-r	30	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
4	10	e	es-r	26	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
5	unknown	e	es-r	23	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
6	10	e	es-r	12	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
7	unknown	e		25	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
8	nya	e	es	12		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
9	nya	e	es	25		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
10	0	e	es-r	12	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
11	0	e	es-r	14	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
12	unknown	e/c		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
13	0	e	es	20		Type 5	0	0	0	0	0	1	0	0	0	0	0	0
14	15	e	es-r	17	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
15	15	e	es-r	17	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
16	15	e	es-r	28	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
17	0	e	es-r	15	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
18	0	e	es-r	14	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
19	0	e	es-r	14	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
20	0	e	es-r	14	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
21	0	e	es-r	14	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
22	15	e	es-r	14	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
23	nya	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
24	0	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
25	0	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
26	0	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
27	0	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
28	0	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
29	0	e		7	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
30	0	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
31	nya	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
32	nya	e		7	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
33	nya	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
34	0	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
35	0	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
36	nya	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
37		c	es-r	35	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
38		c	es-r	23	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
39		c		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
40		c		10	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
41		c		10	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
42	0	e		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
43		c		10	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1

LANDSLIDE CLASSIFICATION INVENTORY

ID	Shoulder to Scarp Distance (ft)	Slope Type	Varnes Classification	Depth of OB/FS (ft)	LANDSLIDE CLASSIFICATION		Landslide Classification Break-down											
					Earth Slump on Bedrock	Earth Slump	Type 1	Type 1b	Type 2	Type 3	Type 4	Type 5	Type 5b	Type 6	Type 7	Type 8	Type 9	unknown
44		c		10	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
45	nya	e	es	18		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
46	nya	e	es	18		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
47	nya	e	es	18		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
48	nya	e	es	18		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
49	nya	e	es	25		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
50	nya	e	es	25		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
51	0	e	es	15		Type 5	0	0	0	0	0	1	0	0	0	0	0	0
52	nya	e	es	10		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
53	nya	e	es	15		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
54	nya	e	es-r	16	Type 1b		0	1	0	0	0	0	0	0	0	0	0	0
55		c	es	14		Type 7	0	0	0	0	0	0	0	0	1	0	0	0
56		c	es	50		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
57	20	e	es-r	20	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
58	20	e	es-r	25	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
59	unknown	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
60	unknown	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
61	unknown	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
62	10	e	es-r	10	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
63		c	es-r	15	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
64		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
65		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
66		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
67		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
68		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
69		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
70	0	e	es-r	13	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
71	37	e	es-r	23	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
72	0	e	es-r	25	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
73	unknown	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
74	unknown	e		18	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
75		c		14	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
76		c		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
77	unknown	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
78	unknown	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
79	unknown	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
80	unknown	e		37	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
81	unknown	e		34	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
82	unknown	e		25	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
83		c		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
84	unknown	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
85	0	e		30	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
86	10	e	es-r	44	Type 4		0	0	0	0	1	0	0	0	0	0	0	0

LANDSLIDE CLASSIFICATION INVENTORY

ID	Shoulder to Scarp Distance (ft)	Slope Type	Varnes Classification	Depth of OB/FS (ft)	LANDSLIDE CLASSIFICATION		Landslide Classification Break-down											
					Earth Slump on Bedrock	Earth Slump	Type 1	Type 1b	Type 2	Type 3	Type 4	Type 5	Type 5b	Type 6	Type 7	Type 8	Type 9	unknown
87	20	e	es-r	30	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
88	0	e		50	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
89	10	e	es-r	17	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
90	0	e/c	es-r	20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
91	25	e	es-r	8	Type 2		0	0	1	0	0	0	0	0	0	0	0	0
92	0	e	es	10		Type 5	0	0	0	0	0	1	0	0	0	0	0	0
93	0	e		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
94	0	e		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
95		c		75	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
96	8	e		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
97	0	e	es-r	30	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
98	0	e	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
99	0	e	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
100		c	es-r	33	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
101	15	e	es-r	12	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
102	unknown	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
103	0	e		17	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
104	0	e		30	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
105	0	e		10	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
106	0	e		10	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
107		c	es-r	10	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
108		c	es-r	12	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
109		c	es-r	12	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
110		c	es-r	8	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
111	0	e	es-r	25	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
112		c	es	unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
113		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
114		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
115		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
116		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
117		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
118		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
119		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
120		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
121		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
122		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
123		c	es	unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
124		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
125		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
126		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
127		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
128		c	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
129	nya	e	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0

LANDSLIDE CLASSIFICATION INVENTORY

ID	Shoulder to Scarp Distance (ft)	Slope Type	Varnes Classification	Depth of OB/FS (ft)	LANDSLIDE CLASSIFICATION		Landslide Classification Break-down											
					Earth Slump on Bedrock	Earth Slump	Type 1	Type 1b	Type 2	Type 3	Type 4	Type 5	Type 5b	Type 6	Type 7	Type 8	Type 9	unknown
130	0	e	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
131	nya	e	es	75		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
132		c	es-r	3	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
133		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
134		c	es-r	10	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
135		c	es-r	2	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
136		c	es-r	9	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
137	unknown	e	es-r	6	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
138	unknown	e	es-r	6	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
139		c	es-r	10	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
140		c	es-r	8	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
141		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
142		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
143		c	es-r	6	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
144	nya	e	es-r	8	Type 1b		0	1	0	0	0	0	0	0	0	0	0	0
145		c	es-r	7	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
146		c	es-r	4	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
147		c	es-r	unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
148		c	es-r	2	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
149		c	es-r	3	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
150		c	es-r	7	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
151	0	e	es-r	12	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
152		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
153		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
154		c	es-r	8	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
155		c	es-r	3	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
156		c	es-r	2	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
157		c	es-r	6	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
158		c	es-r	12	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
159		c	es-r	8	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
160		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
161		c	es-r	2	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
162		c	es-r	4	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
163		c	es-r	3	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
164	nya	e	es-r	8	Type 1b		0	1	0	0	0	0	0	0	0	0	0	0
165	0	e	es-r	14	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
166		c	es-r	9	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
167		c	es-r	13	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
168		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
169		c	es-r	3	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
170		c	es-r	4	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
171		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
172		c	es-r	12	Type 3		0	0	0	1	0	0	0	0	0	0	0	0

LANDSLIDE CLASSIFICATION INVENTORY

ID	Shoulder to Scarp Distance (ft)	Slope Type	Varnes Classification	Depth of OB/FS (ft)	LANDSLIDE CLASSIFICATION		Landslide Classification Break-down											
					Earth Slump on Bedrock	Earth Slump	Type 1	Type 1b	Type 2	Type 3	Type 4	Type 5	Type 5b	Type 6	Type 7	Type 8	Type 9	unknown
173		c	es-r	2	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
174		c	es-r	2	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
175		c	es-r	3	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
176		c	es-r	15	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
177	0	e	es-r	13	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
178		c		25	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
179		c		25	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
180	10	e	es-r	19	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
181	nya	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
182	nya	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
183	nya	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
184		c	es-r	12	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
185		c	es-r	10	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
186		c	es-r	6	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
187		c	es-r	9	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
188		c	es-r	9	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
189		c	es-r	9	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
190		c	es-r	25	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
191		c	es-r	8	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
192		c	es-r	25	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
193		c	es-r	9	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
194	unknown	e		4	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
195	10	e	es-r	20	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
196	unknown	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
197		c	es-r	9	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
198	0	e	es-r	20	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
199	0	e	es-r	20	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
200	0	e	es-r	20	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
201		c	es-r	20	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
202	nya	e		13	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
203	0	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
204		c	es	30		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
205		c	es	30		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
206	nya	e	es-r	18	Type 1b		0	1	0	0	0	0	0	0	0	0	0	0
207		c	es-r	unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
208		c		19	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
209	nya	e	es	18		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
210	0	e		25	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
211		c		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
212		e/c	es-r	17	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
213		c	es-r	10	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
214		c		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
215		c		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1

LANDSLIDE CLASSIFICATION INVENTORY

ID	Shoulder to Scarp Distance (ft)	Slope Type	Varnes Classification	Depth of OB/FS (ft)	LANDSLIDE CLASSIFICATION		Landslide Classification Break-down											
					Earth Slump on Bedrock	Earth Slump	Type 1	Type 1b	Type 2	Type 3	Type 4	Type 5	Type 5b	Type 6	Type 7	Type 8	Type 9	unknown
216	14	e	es-r	13	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
217		c	es-r	10	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
218		c	es-r	10	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
219	0	e	es	unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
220	0	e	es	unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
221	0	e	es	unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
222		c	es-r	17	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
223		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
224		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
225		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
226		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
227	10	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
228	5	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
229	10	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
230	10	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
231	20	e	es-r	12	Type 1		1	0	0	0	0	0	0	0	0	0	0	0
232		c	es-r	8	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
233		c	es-r	8	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
234		c	es-r	10	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
235	nya	e	es	6		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
236	nya	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
237	0	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
238		c	es	unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
239	0	e	es	40		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
240	0	e	es	10		Type 5	0	0	0	0	0	1	0	0	0	0	0	0
241	0	e	es	13		Type 5	0	0	0	0	0	1	0	0	0	0	0	0
242	nya	e	es	13		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
243	nya	e	es	5		Type 5b	0	0	0	0	0	0	1	0	0	0	0	0
244	0	e	es	8		Type 5	0	0	0	0	0	1	0	0	0	0	0	0
245	nya	e	es-r	33	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
246	nya	e	es-r	38	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
247	nya	e	es-r	39	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
248		c		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
249		c		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
250		c		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
251		c		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
252		c		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
253		c	es-r	23	Type 4		0	0	0	0	1	0	0	0	0	0	0	0
254		c	es-r	8	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
255		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
256		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
257		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
258		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0

LANDSLIDE CLASSIFICATION INVENTORY

ID	Shoulder to Scarp Distance (ft)	Slope Type	Varnes Classification	Depth of OB/FS (ft)	LANDSLIDE CLASSIFICATION		Landslide Classification Break-down											
					Earth Slump on Bedrock	Earth Slump	Type 1	Type 1b	Type 2	Type 3	Type 4	Type 5	Type 5b	Type 6	Type 7	Type 8	Type 9	unknown
259		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
260		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
261		c	es-r	5	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
262		c	es-r	unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
263	0	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
264	nya	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
265	nya	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
266	0	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
267	0	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
268	0	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
269	0	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
270	0	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
271	0	e		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
272	10	e		50	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
273	nya	e		50	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
274	nya	e		50	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
275		c		15	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
276		c		16	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
277	15	e		17	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
278	20	e		20	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
279		c	es-r	unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
280	nya	e	es-r	20	Type 1b		0	1	0	0	0	0	0	0	0	0	0	0
281	nya	e	es	50		Type 8	0	0	0	0	0	0	0	0	0	1	0	0
282		c	es-r	14	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
283		c		unknown	unknown	unknown	0	0	0	0	0	0	0	0	0	0	0	1
284		c	es-r	15	Type 3		0	0	0	1	0	0	0	0	0	0	0	0
						Totals	*26*	*5*	*2*	*70*	*20*	*6*	*11*	*0*	*1*	*28*	*0*	*115*

LEGEND

e- embankment
c- cut slope
es- earth slump
es-r- earth slump on rock
e/c- embankment & cut slope
nya- not yet applicable; scarp is below roadway shoulder

APPENDIX D

COST SUMMARY OF INDOT LANDSLIDE REMEDIATION PROJECTS

Compiled by Tarlochan Bansi and Brad Steckler, INDOT Engineering Assessment Section

Date of Letting	Contract Number	DES. Number	Road	Length	County	District	Cost	Type of Correction	Name of Landslide	Cost per ft of repair
5/3/72	R-9047	-	I-65	686	Marion	Greeneville	$38,450.00		Emergency Slide	$56
7/27/72	R-9083	-	I-74	787	Dearborn	Seymour	$586,332 25	key, berm, bench w/ drains	River Slide	$745
10/10/72	R-9171	-	I-74	998	Dearborn	Seymour	$669,485 60	key w/berm horizontal drains	Chicken Slide	$671
3/20/73	R-9342	-	I-65	655	Marion	Greeneville	$30,012 50	No. 2 stone fill on side slope	11th St. Exit Ramp	$46
9/25/73	R-9504	-	I-65	655	Marion	Greeneville	$264,987.50	bin wall	16th St.	$405
6/4/74	R-9828	-	I-74		Dearborn	Seymour	$326,636 91	stone fill on side slopes	Co. Rd. Slide	
9/17/74	R-9895	-	SR 262	496	Ohio	Seymour	$250,650.90	double key	Rising Sun Slide	$505
3/25/75	R-9931	-	SR 662	649	Warrick	Vincennes	$159,238 47	bin wall	Newburgh Slide	$245
6/9/75	R-10198	-	SR 48	113	Dearborn	Seymour	$75,912.00	drilled piers	-	$675
8/26/75	R-10280	-	I-64		Floyd	Seymour	$180,428 10	key	Clothesline slide	
1/18/77	R-10785	-	US 40		Putnam	Crawfordsville	$297,075.86	-	-	
4/18/78	R-11489	-	SR 57	449	Pike	Vincennes	$348,434 40	-	Petersburgh	$776
7/25/78	R-11558	-	I-64	544	Perry	Vincennes	$448,526.50	-	-	$825
10/24/78	R-11786	-	SR 662	697	Warrick	Vincennes	$133,029 95	bin wall	-	$191
5/15/79	R-11964	-	SR 45 & SR 58	296	Greene	Vincennes	$269,851.25	-	Doan Slide	$913
7/24/79	R-12228	-	SR 1	1204	Dearborn	Seymour	$457,031.75	key	Guilford #3	$380
5/13/80	R-12448	-	SR 1	725	Dearborn	Seymour	$264,457.00	-	Guilford #4,#5	$365
1/20/81	R-12874	-	I-74	1151	Dearborn	Seymour	$892,691.09	-	-	$776
5/15/84	R-14622	8344750	SR 662	400	Warrick	Vincennes	$384,560 23	rock key	Newburgh	$961
11/15/88	R-17823	7930740	SR 37	1300	Crawford	Vincennes	$1,547,141.19	bin wall	Long Hollow	$1,190
11/14/89	R-17604	8145330	SR 37	900	Orange	Vincennes	$465,470.00	rock key	Paoli	$517
5/15/84	R-14504	835700	SR 56	1100	Jefferson	Seymour	$750,861 00	rock backfill	-	$683
12/18/90	R-19173	8353110	US 50	185	Dearborn	Seymour	$451,774 00	rip rap	-	$2,442
2/20/96	R-21469	8100530	SR 56	810	Dearborn	Seymour	$2,268,654.40	tieback drilled piers	-	$2,801
5/14/96	R-22146	9502900	I-69	3383	Madison	Greeneville	$543,056 21	2988' reinforced backfill 394' soil benching	-	$161
8/22/97	R-23132	9607930	SR 66	565	Perry	Vincennes	$1,157,879 70	300' drilled piers 265' rock key	-	$2,049
4/7/98	R-23258	8353080	SR 48	330	Dearborn	Seymour	$383,299 15	rock key	-	$1,162
6/11/98	R-23368	4612560	SR 56	2858	Jefferson	Seymour	$4,671,891.76	tieback drilled piers	-	$1,635
present	-	8013380	SR 56	154	Switzerland	Seymour	$303,000.00	tieback drilled piers	-	$1,968
present	-	9413381	SR 56	2297	Switzerland	Seymour	$2,660,000 00	drilled piers	-	$1,158
present	-	9611790	SR 129	400	Switzerland	Seymour	$337,100 00	rock key	-	$843
									Average cost of excavation and backfill method for 1989 to present (highlighted figures)	**$1,129**

APPENDIX E

Guidelines for Railroad Rails Used as Retaining Structures

GUIDELINES FOR RAILROAD RAILS USED AS RETAINING STRUCTURES

Railroad rails have been used for years on maintenance projects involving landslides along roadway shoulders. The results have been variable. Probably a major portion of the problems with the use of rail piles has been the lack of standardized design and construction procedures. The variables of rail size, rail spacing, maximum length and required embedment are critical in obtaining maximum efficiency. It is to this purpose these quidelines are being made available.

It has been found from engineering experiences and analyses that laterally loaded piles operate in an optimum fashion when they are embedded at least a minimum length into stable material and are not allowed to become overstressed. Very often, rails in use as piling have been driven to refusal which may not always be satisfactory for complete embedment. Also, too large a space between the piles will not allow the soil to "arch", thus the soil will slide through them. Rails used at too great a depth will become overstressed and fail.

These guidelines are an effort to assist maintenance engineers in their choice of where to use rail piles and how to design for soil arching, rail spacing, and how to correctly install them.

GENERAL GUIDELINES CONCERNING THE USE OF RAILS AS PILING

A. Railroad rail piling is intended for use on landslides affecting roadway shoulders and a limited amount of the driving lanes. If the distance from the shoulder to the furthest breaks in the pavement is greater than the depth to rock, the use of rails may not be practical.

B. The design charts and typical details included in these guidelines assume the failure surface to be at the depth to rock. The determination of the depth to rock should be made with auger borings.

C. If the depth of the failure surface is less than the depth to rock, and if the failure surface is known to have underlying firm stable soil, then the depth to the firm stable soil may be used in the charts in lieu of the depth to rock.

D. The minimum length of embedment into rock or firm stable soil shall be approximately one-half the free end length. (The free end length being the distance from the ground to the assumed failure surface.) This is to assure proper fixation of the rail. The depth of the hole should be slightly greater than the length of rail to be installed. Debris falling into the hole may fill up a portion of the bottom and prevent proper embedment length.

E. The maximum spacing of the rails should be 121.920 cm (48 inches) from center-to-center. This is to insure that the soil will not flow between the piles. The minimum spacing of the holes should be 60.960 cm (24 inches) center-to-center.

F. When more than one row of rails is required, the holes should be staggered evenly as shown on the attached drawing. The spacing between the rows should be as close as possible. A spacing of approximately 60.960 cm (24 inches) is desirable in order to allow the rows to act as a unit in retaining the sliding mass.

G. Care must be taken to insure the flanges on the rails are positioned perpendicular to the direction of the landslide to utilize the full strength of the rail cross section.

H. After the rail has been placed in the hole, the hole is to be backfilled with concrete, sand, peagravel, crushed limestone, or crushed sandstone as availability and economics dictate. Generally, auger tailings are not permitted as backfill materials. The backfill is to be shoveled or dropped in small amounts into the hole to prevent voids from forming around the rails.

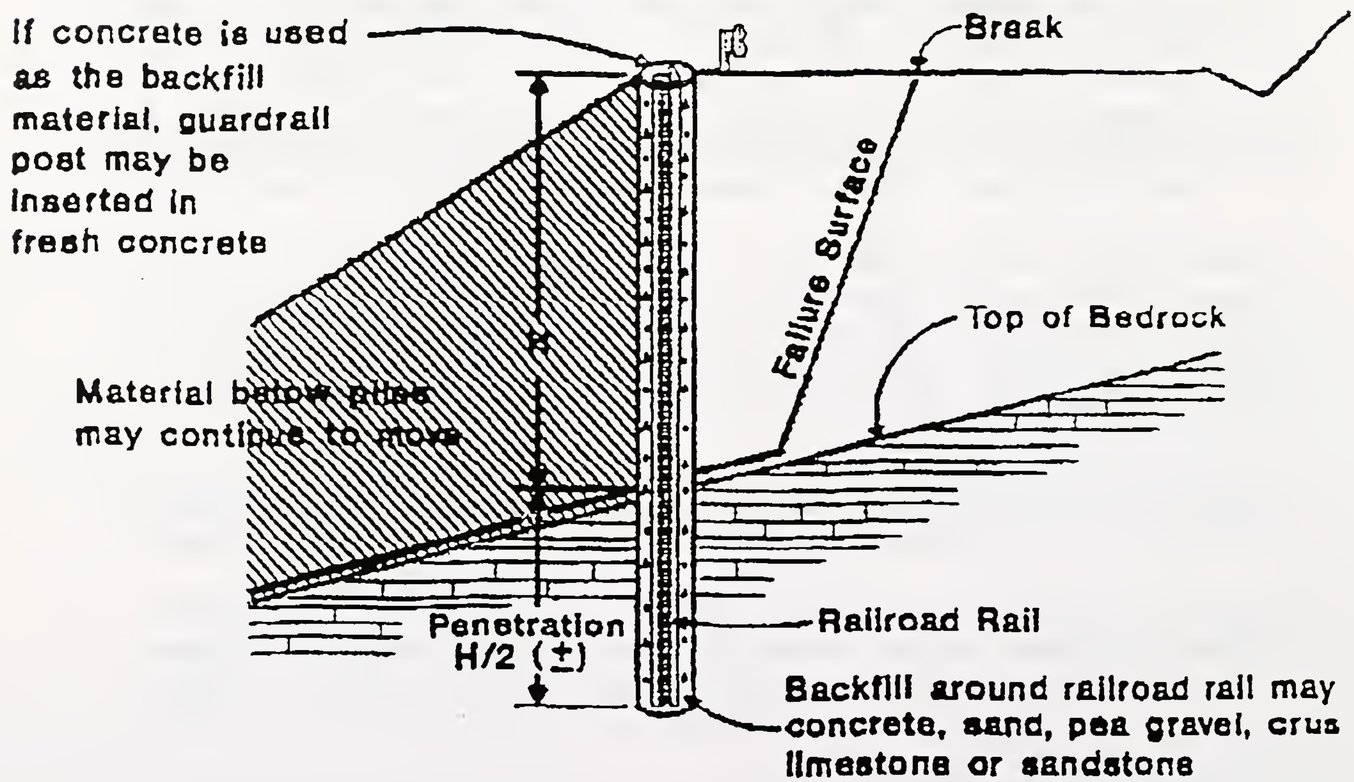
GENERAL GUIDELINES CONCERNING THE USE OF RAILS AS PILING (CONTINUED)

I. If backfilling in the affected roadway and shoulder is necessary, care should be used not to damage the rails during placement and compaction of the backfill. Lightweight fill materials such as lightweight concrete or flyash should be used when possible.

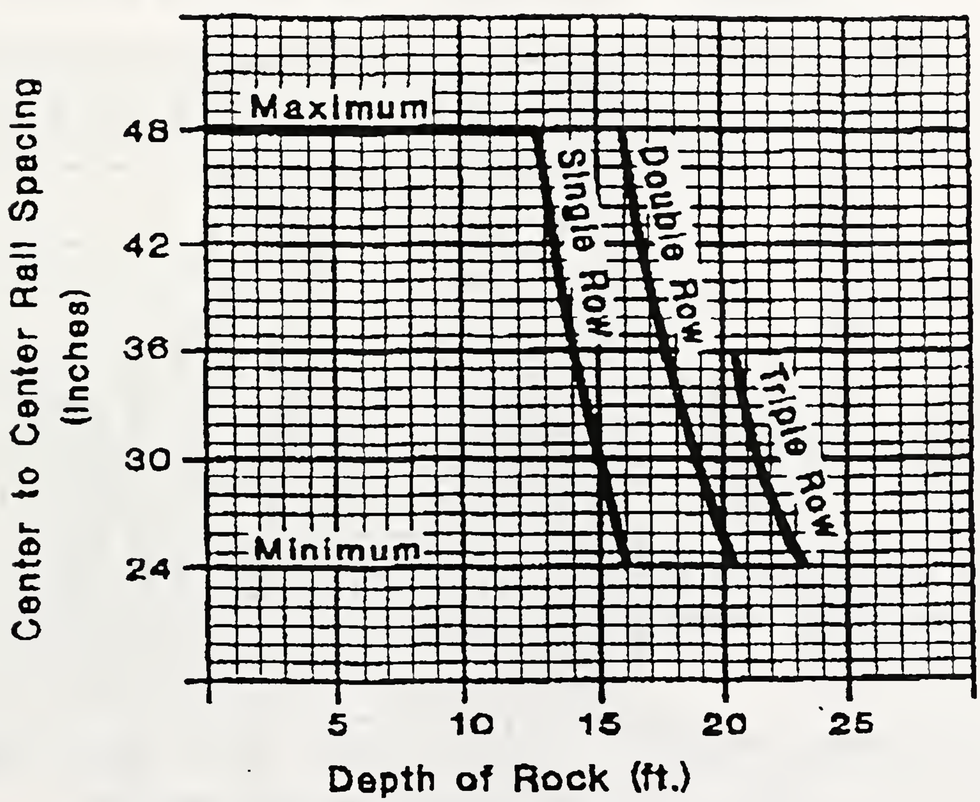
J. In some cases backfilling may require the attachment of lagging to the rails to retain the backfill material. If wood lagging is to be used, the wood should have adequate size, strength, and durability. Used guardrail may be used as lagging. Geogrids, such as Tensar Biaxial Geogrid BX1100 (or equal) may also be used. If a geogrid is used, the gradation of the backfill must be large enough to prevent its passing through the geogrid.

K. The slopes beneath the supported sections must not be subject to severe erosion. Suitable erosion control must be established on the slope if rail piling is to be used.

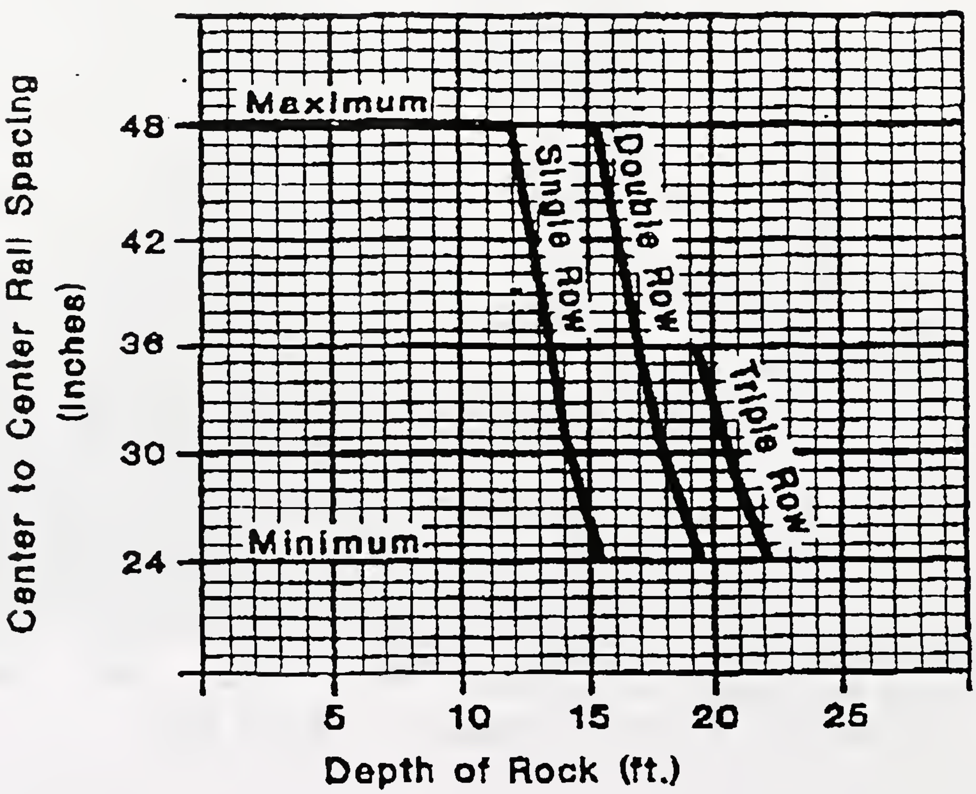
TYPICAL SECTION DEPICTING INSTALLATION OF RAILROAD RAIL PLACED IN DRILLED SOCKET FOR LANDSLIDE CORRECTION



Design Chart for 136 to 140 lb./yd. Rails

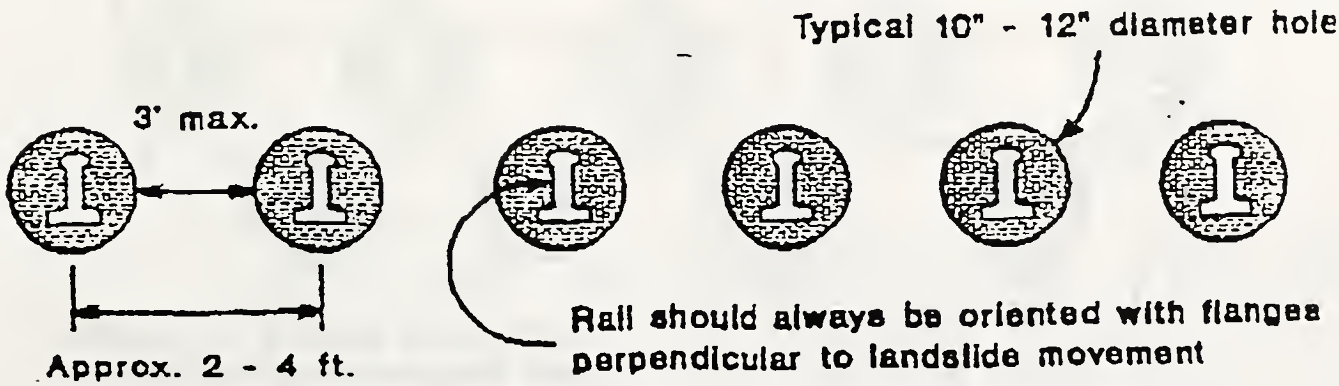


Design Chart for 130 to 133 lb./yd. Rails



ALTERNATE SCHEMES FOR INSTALLING RAILROAD RAILS PLACED IN DRILLED SOCKETS

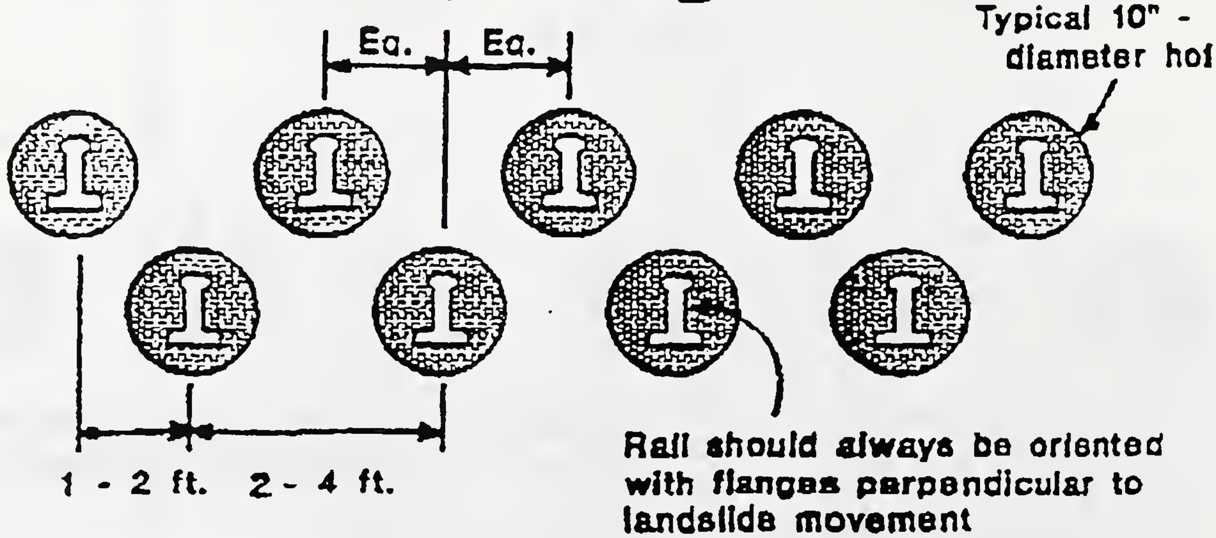
Scheme I



One row may be used when the effective spacing varies from approximately 2 - 4 ft.

ALTERNATE SCHEMES FOR INSTALLING RAILROAD RAILS PLACED IN DRILLED SOCKETS

Scheme II



Two or more rows should be used when the effective spacing is less than 2 feet.

IDENTIFICATION OF RAILROAD RAIL SIZES

1. Typically classified in units of lbs-per-yard.

   Examples :

   155 lbs/yd, 140 lbs/yd, 132 lbs/yd, 90 lbs/yd

2. Each rail has a classification stamped in web.

   Example :

   112 25 RE OH ILLINOIS USA 1935 IIIIII

   Weight in lbs/yd

LIMITATIONS

- ★ Depth to formation should not be greater than 7.010 m (23 feet).
- ★ Restricted to slides affecting one driving lane.
- ★ Severe erosion of slopes cannot be allowed.
- ★ Assumes failure surface at depth of formation.
- ★ No Factor-of-Safety included into design charts.

APPENDIX F

CONTACT INFORMATION OF PROFESSIONAL & ACADEMIC PERSONNEL INQUIRED

Conventional Horizontal Drains
Jeff Jensen
Jensen Drilling
230 Cusick Road
Alcoa, TN 37701
Phone: (423) 984-4627
Fax: (423) 970-3151
e-mail: sales@jensendrilling.com
web: www.jensendrilling.com

Horizontal Wick Drains
Dr. Paul Santi
Department of Geological and Petroleum Engineering
University of Missouri-Rolla
129 McNutt Hall
Rolla, MO 65409
Office: (573) 341-4927
Secretary: (573) 341-4867
Fax: (573) 341-6935
e-mail: psanti@umr.edu
web: www.umr.edu/~psanti

Lime Piles
Edward Forte
Stabilator USA, Inc.
Maspeth, NY 11378
Phone: (718) 786-3350
Fax: (718) 786-3329
e-mail: ed.forte@stabilator.com
web: www.stabilator.com

Driven Recycled Plastic Pins
Dr. Erik Loehr
Assistant Professor of Civil Engineering
University of Missouri-Columbia
Phone: (573) 882-6269
Fax: (573) 882-4784
e-mail: eloehr@missouri.edu

Railroad Rail Piles
Doug Smith
Kentucky Department of Transportation
1236 Wilkinson Blvd.
Frankfort, KY 40601-1200
Phone: (502) 564-2374
Fax: (502) 564-4839
e-mail: dsmith2@mail.kytc.state.ky.us

John Bowlin
Transportation Engineer, Branch Manager
Kentucky Department of Transportation
P.O. Box 2468
Pikeville, KY 41502
Phone: (606) 433-7791
Fax: (606) 433-7765
e-mail: jbowlin@mail.kytc.state.ky.us

Gravity Mass Retaining Systems
John Wolosick
Branch Manager
Hayward Baker Inc.
419 Crossville Road, Suite 101
Roswell, GA 30075-3000
Phone: (770) 645-9400
Fax: (770) 645-9401
e-mail: jrwolosick@haywardbaker.com

John Sidney Davis
Vice President
Schnabel Foundation Company
1654 Lower Roswell Rd
Marietta, GA 30068
Phone: (770) 971-6455
Fax: (770) 977-8530
e-mail: jsiddavis@cs.com
web: www.schnabel.com

Mechanically Stabilized Earth
David Wheeler
Wheeler Corporation
841 Elston Drive
Shelbyville, IN 46176
Phone: (317) 398-7500
Fax: (317) 298-0282
e-mail: wheeler@theinnet.net

Biotechnical Remediation

George Athanasakes
FMSM Engineers
1901 Nelson Miller Pkwy.
Louisville, KY 40223-2177
Phone: (502) 244-6519
Fax: (502) 244-8826
e-mail: gathanasakes@fmsmeng.com

Excavation and Backfill Method Cost Estimate and Cost Summary

Indiana Department of Transportation

Tarlochan S. Bansi
Supervisor Engineering Assessment Section
Preliminary Engineering and Environment Division
IGCN
100 N. Senate Ave. Rm. N848
Indianapolis, IN 46204-2218
Phone: (317) 232-5470
Fax: (317) 232-5478
e-mail: tbansi@indot.state.in.us

Brad Steckler
Manager Engineering Assessment Section
Preliminary Engineering and Environment Division
IGCN
100 N. Senate Ave. Rm. N848
Indianapolis, IN 46204-2218
Phone: (317) 232-5137
Fax: (317) 232-5478
e-mail: bsteckler@indot.state.in.us

Vladimir Ilyin
Highway Engineer Supervisor
Design Division
IGCN
100 N. Senate Ave. Rm. N848
Indianapolis, IN 46204-2216
Phone: (317) 232-5228
Fax: (317) 233-4929

Other State Departments of Transportation Inquired

Illinois Department of Transportation

Dr. Riyad Wahab
Head Geotechnical Engineer
126 East Ash
Springfield, IL 62704
Phone: (217) 782-7207
Fax: (217) 782-2572
e-mail: wahabrm@nt.dot.state.il.us

Ohio Department of Transportation

Jean Gieger
Geotechnical Design Coordinator
1600 West Broad St. Rm. 2033
Columbus, OH 43223
Phone: (614) 275-1318
Fax: (614) 275-1354
e-mail: geiger@odot.dot.ohio.gov

Tennessee Department of Transportation

Leonard Oliver
Engineering Manager-Geotechnical Division
TDOT Materials and Tests Division
6601 Centennial Blvd.
Nashville, TN 37243
Phone: (615) 350-4101
Fax: (615) 350-4128

West Virginia Department of Transportation

Greg Bailey
Head Geotechnical Engineer
West Virginia Department of Transportation
State Complex Bldg. 5 Rm. 650
1900 Kanawha Blvd. East
Charleston, WV 25305
Phone: (304) 558-0601
Fax: (304) 558-4344
e-mail: gbailey@dot.state.wv.us